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PSYCHE

VOL. XXXVI SEPTEMBER, 1929 No. 3

THE BIOLOGY AND BEHAVIOR OF MINING BEES, *ANTHOPHORA ABRUPTA* AND *ENTECHNIA TAUREA.*

By Phil Rau

Kirkwood, Mo.

Introduction

This paper deals with the behavior and biology of two species of mining bees, *Anthophora abrupta* and *Entechnia taurea,* with brief notes on *Anthophora raui.* Large colonies of these three bees carried on their mining operations in a sheltered clay bank at Wicks, Mo. All three species were also important factors in the life of this microcosm (the clay bank community), and their relations, interrelations and reactions to environment have been studied and reported in a paper entitled "The Ecology of a Sheltered Clay Bank: a Study in Insect Sociology."[1] In making an ecological study of that kind, one often faces difficulty in deciding just which data to publish under the title ecology, and which rightfully belongs to biology or behavior. Hence I tried to sift out for that paper the data on ecology, and all the remaining material, which more properly belongs to biology and behavior, is published herewith. Since the reader may not always agree with me in my arbitrary classification of data, and since I have tried not to repeat in this paper the data already published under the title "Ecology," I can only recommend that he read the Academy of Science article in connection with the present one.

[1] Trans. Acad. Sci. St. Louis, 25:159-276. 1926.

The clay bank (fig. 2) at which these bees (figs. 5, 6 and 7) were nesting, faced the east, where it received the morning sun, and was protected from the weather by the porch above it.

THE TURRET-BUILDING BEE, *Anthophora abrupta*.

Anthophora abrupta makes no secret of its presence. They are neither timid nor aggressive, but they certainly are self-reliant. Their presence is easily and quickly detected by two prominent indicators, the bees themselves, and the conspicuous nests which they build. A glance at the picture (fig. 5) will convey to the reader some idea of how conspicuous they are as they noisily swing their ponderous bodies to and fro on the wing, arrive home and scramble into their burrows or come tumbling out headlong and dash off into the sunny fields, with all the exuberance of boys just out of school. They have none of the shy, stealthy ways of maneuvering, whereby some of the smaller and daintier varieties of bees and wasps hold their own in a competitive world. They go boldly and fearlessly about their work, and soon construct nests which are likewise prominent. While many species of solitary wasps and bees try in some way to conceal the location of their burrows, these construct large mud chimneys over their nests, made from the clay dug out of the burrows (fig. 1). Since they work in colonies, or more correctly remain to build on the site where they were born, the result is a very conspicuous village, sometimes a very crowded and busy town of these masonry turrets as shown in profile in fig. 8. At a busy season when many of these huge bees are bustling about with very audible hum and zip, the entire village with its many wonderful towers and industrious citizens form a spectacle which is in itself quite capable of overawing any but the most unemotional individual.

In 1917 the *Anthophora abrupta* first appeared on June 25th. In 1918, the spring was warmer and they were out and at work much earlier, and the size of the chimneys indicated that they must already have been at work some days before I discovered them on May 28th.

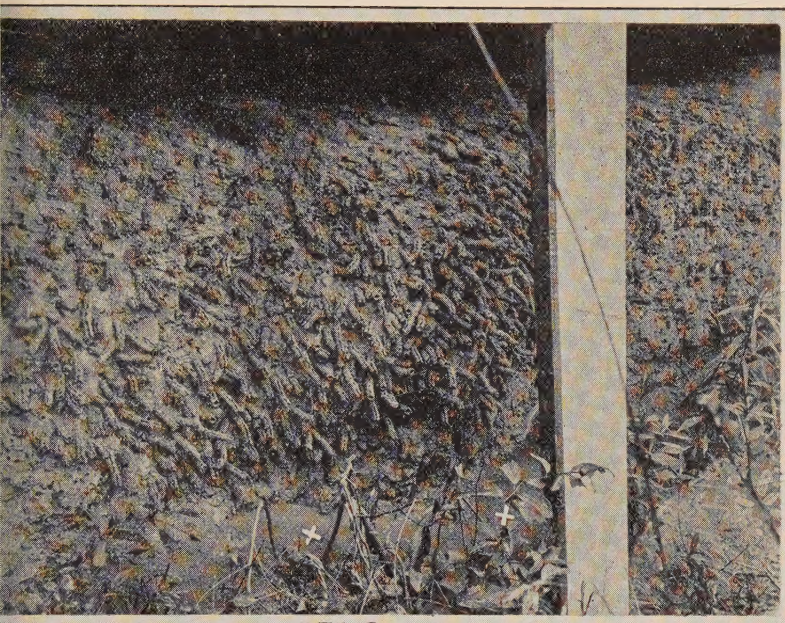

FIG. 1

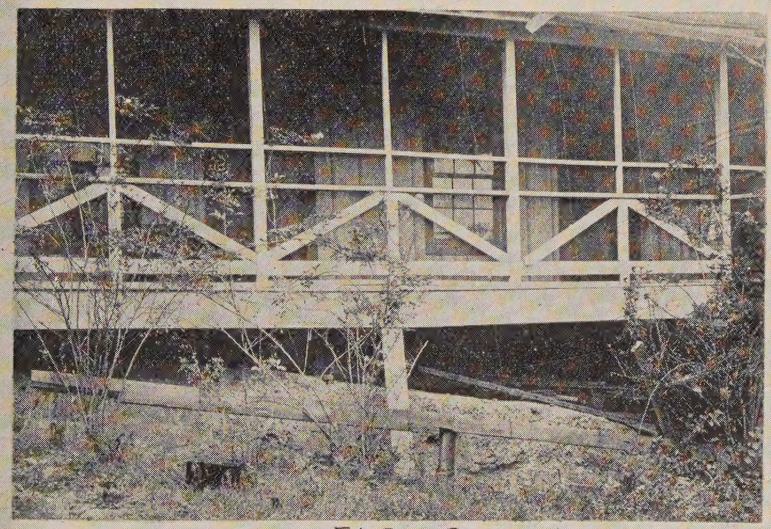

FIG. 2

Fig. 1. The work of *Anthophora abrupta*. Turrets built over their nests.
Fig. 2. The clay bank under the porch where the three species of mining bees nested.

In the spring of 1921 the males were found flying on May 27th, when they were frequently seen on the flower-buds of the rambler roses. Often they seemed to be trying to bite their way into the buds. At evening they were often seen to climb to the top of a grass-blade, grasp the tip firmly in their jaws and go to sleep. Fig. 3 shows a male sipping sugar water from a piece of cotton.

Fig. 3. The male of *Anthophora abrupta*.

I have never seen mating occur at the bank, and I have often wondered if they do not go elsewhere for the purpose of meeting the females. At a point about one hundred yards distant, on a hill side facing the eastern sun, I repeatedly saw a number of males hovering and flitting over a barren spot about three feet square covered with old rusty slag. At first I suspected that this was the place of their courtship-dances, but I failed ever to discover a female there. Instead the males were often found devoting their attention to the rust-covered ashes, to which they clung with their jaws. That reminded me how the females of their species at Manchester, Mo., during the previous summer had shown astonishing persistence in eating the rust from an old iron barrel-hoop and rusty fence-wire. Perhaps these males merely went to this bed of cinders to get their supply of mineral salts while the females were emerging and prospecting for burrows. This habit of licking rusty objects was not merely a casual occurrence but a purposeful and persistent activity; it elsewhere attracted the notice of my companion, who

suggested that carnivouous insects can derive their mineral salts from the blood and juices of their food, but these mining-bees are nectar feeders; hence it is possible that they may need to obtain their necessary mineral salts by some such direct methods as this.

On the next day the persimmon blossoms were beginning to open and already the bees had turned their attention thither; within three or four days more they were intensely active at this new task. In this short time, less than a week, the males had disappeared. Thus in a short while, and in keeping with the rapidity with which this species lives and does things, the males had come and gone, and the females remained buzzing at their new work. They hummed and danced in the sunlight in front of the bank; this activity, however, was not a courtship dance such as occurs in other insect species, but merely the industrious search in flight before the face of the bank as each bee tried to distinguish her own burrow. It was not a simple task at so early a time in the season, and it gave rise to more commotion than later when the bees had had more experience. If one singled out an individual in the crowd and continuously followed it with the eye, one would see that it finally plunged into an opening, sometimes to remain and sometimes to come precipitously tumbling out again and try another. It is little wonder that the returning bees must spend some time in distinguishing their own nest among hundreds or even thousands of burrows, but my observations have substantiated my expectation that later in the season, when the turrets were nearly all built, they would consume less and less time in this orienting dance as they learned more readily to distinguish their own nests among the hundreds in the group. I have stated elsewhere that when these bees came home late in the evening, their hovering in front of the nests was much prolonged, owing to their difficulty in finding their way in the fading light. A number of the larger turrets and their occupants were marked; these were watched in comparison with the rest of the population. It was soon apparent that those with large turrets found their homes with much less hesitation than the turretless ones.

Hence I sometimes wonder, since I have never yet learned

the utility of these chimneys, whether they might not be built to serve as landmarks for the returning bees. The variation in the size, shape and position of these turrets was much more apparent than that of the mere apertures in the bank. The turrets ran in various directions; some were horizontal, some tilted a little downward, others were at various angles toward north and south. There seemed to be no plan or scheme of direction, except that none were seen with an upward tilt, but the points of the compass were utterly disregarded, (see figs. 1, 4, and 8) and so far I have been unable to discover any factor, light, convenience, efficiency, or anything else, that could determine the direction in which these chimneys curved as they grew. Their diameter, (fig. 11) about ½ inch outside measurement, was fairly uniform for the entire colony, but their length varied from nothing to three inches, the greatest number of finished ones measuring about two and one-half inches in length. None of the tubes were found to be closed either at the base or at the orifice of the chimney; the entire channel leading down to the cells was in every case hollow, with an open groove for its full length along the top. The bees did not tear down the chimney and utilize the material for tunnel-filling as do the *Odynerus geminus* wasps,[1] nor did they even seal the tunnel with a thin wall at the surface of the ground. The tunnels were tortuous and hard to follow, owing to the closeness of the nests and the extreme hardness of the clay. One tunnel was opened which slanted downward, then upward, forming a letter "V" with a total length of five inches. Another, which had a two-inch tube, penetrated the bank to a depth of six and a quarter inches, following a zig-zag course, and terminated in the usual pocket. This mother evidently had lost her nest or had become lost herself before the nest had been completed or used. This was not the only case of this failing; in a number of cells we found this same condition.

But these *abrupta* went further than merely to dig a burrow in the ground and provision it, as do so many species of their kind. Deep down within the tunnels in the

[1] Wasp Studies Afield, p. 299-312, 1918.

solid clay they built distinct cup-shaped or thimble-shaped cells in which they placed the store of prepared pollen and the egg, and then individually sealed them, in this way obviating the necessity of sealing the outside or main tunnel to exclude intruders. This method gave excellent protection against injury by violence and the weather, for the cells containing the eggs or larvae were heavier than the little pots which the potter-wasps attach to twigs, and they equalled in thickness and warmth the mud walls of *Trypoxylon politum* and they had in addition the protection of the deep burrow. These cells were oval, ¾ inch in length, placed close together and were varnished on the inside with some special waxy substance. Fig. 12 shows a lump of mud with these brood pots.

The bees continued to extend the tunnels by excavation and enlarge the chimneys by addition. They brought water from a mud-puddle in the road fifteen feet distant, carrying the load in the gullet. With a portion of the water they would wet the hard, yellow clay, remove a mouthful of it, back out and apply it to the last ring in the chimney. The bees would carry the mud under the thorax with the front pair of legs, while the two hind pairs furnished locomotion; as the bee backed out of the nest to the opening, the ball of mud was passed to the hind legs, and she now held her footing with the front legs while with hind legs she slapped the mud onto the last layer and with many active thumps with the tip of the abdomen, punched and beat it into shape. "Punched" is really the right word correctly to describe the gesture. *Entechnia taurea* does similar work with much finer precision; in that species the bee divides the ball of earth into two portions, applies the first part to the center of the tube at the bottom, and carefully smooths and works it on the left side almost to the top; then she applies the second portion in the same way at the base and works it up on the right side. The result of this method is that, either through the builder having insufficient material, or from some other cause, there remains a split or open groove down the full length on the upper median side of the tunnel, where the two halves of the load of mud fail by only a narrow margin to meet.

The bee here considered, *Anthophora abrupta* also left an opening along the top of most of the chimneys, (figs. 4 and 11)[1] but here it was not due to the method of building followed by *E. taurea,* for *A. abrupta* applied her load of mud wherever she happened to strike the edge, on the bottom or sides, and the job of spreading it was quickly done. In

Fig. 4. A close-up view of the turrets over the nests of *Anthophora abrupta.*

this species the chimney was somewhat greater in diameter, and it was rougher on the outside, but the interior surface was very smooth and neat. Sometimes in her hurry to apply the mud, the bee dropped it; at other times she might be seen brushing out loose, moist materials by kicking them backwards, probably the crumbs or scraps that had dropped

[1] Fig. 4 and 1 show these openings very distinctly, while Fig. 11 does not show so many, because in the latter figure they were inverted when the photograph was made. In most of the turrets in Fig. 11 we see the bottom side.

from the walls in the process of biting out the hard clay, or the scraps that dropped while she fashioned her thimble-like cups.

Unlike the homes of some species, this gallery was roomy enough that the owner could turn around in it, for while she always backed out when she emerged with her load of mud, she did just the opposite when she came out for water, for then she always came out head first and dashed away. One singular feature occurred in the great majority of individuals observed; when they had used up the water, and had applied the last load of mud to the turret, they did not realize their need and fly directly out and away for more water, but re-entered the hole as usual, sometimes stayed in a few minutes and then came out head-first and flew away to the watering place. This might be due to the fact that the bee did not know that the water was gone and must have as a stimulus the experience of biting out the dry soil to arouse her inclination to go for more water. On the other hand, it might be that she entered the hole only to turn around so as to leave head-first, instead of tumbling out backwards as when she had applied her mud. The bees, when they had arrived at the water, did not alight upon the surface as do certain wasps, by spreading their legs, but landed on the soft mud on the margin, and with the long tongue protruding lapped it up. They were not bound by instinct even to go to the same place regularly for water, for one year after a rain many were seen availing themselves promptly of the temporary convenience and gathering the drops from the vegetation very near to their doors, instead of going to their customary place.

The round trip for water consumed from one-fourth to one-half minute, and the number of pellets of mud that could be carried out with each mouthful of water was interestingly varied. One bee which was watched for one hour, from 2:03 to 3:05 p.m. made twelve trips for water, and removed forty-seven balls of mud. When one considers that the mud was not only excavated, but was built into the chimney, one feels that this is a good hour's work for so small a creature. One gulletfull of water would remove 2 to 5 balls of earth, the greatest frequency being 4; this num-

ber occurred six times, five loads occurred three times, three loads twice, while in only one instance did she carry only two loads for one mouthful of water.

Another bee working from 2:03½ to 3:01 p.m. made twelve trips, and carried out 2, 1, 2, 2, 3, 5, 2, 5, 5, 2, 1, 2 loads, or thirty-two balls of earth in 57½ minutes; she was not quite as industrious as the first one. A third one also made twelve trips in the same hour, and carried out 1, 7, 2, 2, 0, 4, 3, 2, 2, 6, 2, and 2, totaling 33 loads. This is sufficient to show that there is no regularity in the number of balls removed.

I was unable to ascertain whether the entire amount of water was ejected at one time and the dirt thereby softened, or whether, as in the wasp *Odynerus geminus*, only a little water at a time was disgorged upon the spot, the mud bitten out, and then another spot moistened.

By the middle of July, I found the *Anthophora abrupta* had entirely disappeared, and some of the chimneys were dropping to the ground beneath. When these bees had completed their work, neither the chimney nor the tunnel was plugged up, and, since the former often dropped through disintegration soon after the work was completed, it seemed that they could serve no utilitarian purpose excepting during nidification. Some of the turrets were built so well that they withstood the winter, remaining intact for a year or more.

Chalcid parasites of the genus *Monodontomerus* were abundant about the bank, loitering about the holes, waiting for the provisioning to take place. They were indolent, and did not even evade when one attempted to take them in the fingers. Many of the empty pupal cases of *Anthophora abrupta* harbored several of these live chalcids. In one cocoon I found twenty living pupae of this parasite on June 28th, and since the adults were plentiful there a month earlier, the finding of the pupae at that date indicated a second generation. On June 24, 1920, several cells of this mining-bee were brought indoors. They were not examined until September 2, when several chalcid parasites emerged. To be exact, there were 109 females and 39 males from four cells, or an average of 35 to each cell. Of the other

nine cells collected, three had dead larvae, five contained dried-up balls of food, and one harbored a parasitic cuckoo-bee.

The "open door policy" of this species sometimes brought its trouble too. Not infrequently an animated fight was to be seen between two females, one evidently trying to usurp the burrow that had been made by another, and often dead bees were found at the foot of the bank. Occasionally a dead one was found in the burrow, and in all probability a second mother, in appropriating the nest, cleared the dead body out with the other rubbish. Frequently, however, the fights appeared quite alarming without proving fatal. One pollen-laden mother was seen backing out of her hole with the front leg of an intruder in her mandibles. The visitor showed no fight, but resisted with all her might; at the foot of the hole, every little gain that the rightful owner made was offset by the intruder pulling her back. At last the intruder lost her hold, and as they went tumbling to the ground they engaged in a pugnacious embrace. Needless to say that the rightful owner lost most of her load of pollen, which deluged the face and head of her antagonist. Another pair was locked in deadly embrace for over twenty minutes, and there seemed no probability of their separating soon. They were so intent that they were unaware of the fact that they were being pushed into a test-tube. After five minutes more of violent struggling in this novel place, they lost their grip for a moment and separated, and when they were liberated, they both flew into the air, little disconcerted by the ordeal.

A. abrupta made nests either with or without turrets, and the turret-making activities were directly correlated with water conditions. They required water in abundance, and when it was plentiful, so too were the turrets; in droughty years they struggled on with few and small or no turrets, and their nesting activities were much reduced. If they had to struggle on with a small drop of water, they consumed much more time in mining than when they could be generous with the water and thoroughly and quickly wet the hard clay. It was pathetic to see the mother back out of her hole with a load of slightly moist soil instead of a load of wet mud;

when she attempted to work it into the turret it would crumble and fall to the ground. The size of the population, it seemed to me, was just as much regulated by the amount of water available as by the number of parasites, for in 1922, when hundreds of bees were at work and the fewest turrets were made, the official statement from the local weather bureau at St. Louis showed that the precipitation for the five months, May to September inclusive, was the least recorded in 85 years.

In another colony, in a different locality, the nests were also built without turrets, but in that case the deficiency was due to lack of clay instead of water. Here the mothers were nesting in the disentegrating mortar of an old stone chimney. Despite the fact that so little turret material was available, and no normal chimneys were made, a good many of the tunnels had a very small ring or collar at the opening.

This bee was almost contemporaneous with *A. raui* (fig. 6) ; however, interbreeding of the two species was not possible. Careful observations in 1922, showed that *A. abrupta* emerged from May 30th to June 2nd, and by June 3rd all the males were dead. *A. raui* did not appear until June 10th, a week after the males of *A. abrupta* were gone. This made it impossible for the males of *A. abrupta* to fertilize the females of *A. raui* and since the females of *A. abrupta* had already been fertilized when the *A. raui* emerged, a second fertilization was improbable. In 1929, the *A. abrupta* population waned on about July 2, and the *A. raui* about July 12.

Since *A. raui* Rohwer is a new species, reported so far only from this particular clay bank, it would be fascinating, if justifiable, to surmise that this habitat is the cradle of the species, an offshoot from *A. abrupta.*

We may cite for comparison some observations on other species of this genus in various localities by different investigators.

Sharp[1] says *Anthophora* is one of the most extensive and widely distributed of the genera of bees. He also points out that Friese has made the discovery that *A. personata*[2] at

[1] Insects. Pt. II, p. 33, 1899.

[2] *A. personata* is now called *A. fulvitarsis* Brulle. (fide T. D. A. Cockerell).

Strasburg takes two years to accomplish the life cycle of one generation. "Some of the species make burrows in cliffs and form large colonies which are continued for many years in the same locality."

Say, in referring to the habits of European *A. parietina,* says that this species digs a hole in a clay bank and that the entrance consists of a cylinder extending downward more than an inch in length and made of small pellets of earth compacted together, rough on the exterior and smooth within.

Hungerford and Williams[1] made note of the nesting habits of *A. occidentalis,* which they call the "larger tube-building cliff bee." The method of nest-building is very similar to that described for *A. abrupta,* for they say: "Their tunnels are 3/8 inch in diameter and extend into the bank about eight inches where they end in several cells. The cells . . are so made that when dug out they come from the gallery as separated urn-shaped nodules of uniform size. The entrance of the tunnel is protected by a curved tube from 3/4 to 2 inches in length. The tubes bend downwards and very often the top or outer curve is split longitudinally." In view of the fact that *Hornia minutifennis* Riley was found to be parasitic on the members of the Wickes colony, it is interesting to learn that these students discovered a new species of beetle, *Hornia gigantea,* parasitic upon *A. occidentalis.*

Frison has discovered a colony of *A. abrupta* near Oakwood, Illinois, and in an interesting paper[2] gives many details of the life history of this species. He finds them nesting in a clay bank, carrying water for mining operations, and on the whole conducting themselves in every way like the bees at our clay bank. His paper includes a valuable review of the American species of *Anthophora.*

Walsh found this species making burrows in the mortar in brick work, and also in the face of a precipitous clay bank. In California, *A. stanfordiana* shows a similar preference for nesting in a steeply inclined surface. They build chimneys over the entrances of their burrows.

[1] Ent. News. 23:258 1912.
[2] Trans. Amer. Ent. Soc. 48: 137-156. 1922.

Latter[1] mentions that *A. pallipes* is abundant in England, and "make their nests in firm banks of sand or clay, if not too wet; their burrows do not extend very deep and contain one or more cells whose outer wall is made very hard, by a cement of sand or clay applied by the female bee after she has completed the commissariat arrangements." We assume that *A. pallipes* does not build turrets at the opening of their nests, for if they do so, it is quite unlikely that so keen an observer would have failed to mention the fact. The same gregarious condition that has been recorded for other species of Anthophora exists in this species, for the author goes on to say that numbers of Anthophora live in the same bank, and on a warm April morning the scene at such a spot is most lively; females are to be seen entering or leaving the burrows intent on business or possibly engaged in a headlong flirtation with males in front of the bank.

Bouvier[2] calls attention to a most interesting point in the behavior of *Anthophora* wherein a species with solitary habits assumes under certain circumstances an attitude ordinarily displayed by social bees, or we might say a step in the evolution from a solitary to a social state. He says that when it is necessary to struggle for the common defense, the European *Anthophora* of the walls becomes singularly aggressive. "Established in sandy, argillaceous soil which it perforates with tubular galleries, this bee comes out in war-like swarms every time one approaches the colonies. Buttel-Reepen relates the misadventure of an entomologist who was pursued a long time by one of these swarms after a badly executed swing of his net; and Friese reports that he himself was attacked for having tried to collect on the walls of a barn where thousands of Anthophora had their nests."

These European Anthophora have, according to this, progressed in their behavior further toward socialization than the American *A. abrupta* and *A. raui*. Here at various times I sat among their nests for days at a time, and these bees did not at any time show a concerted attack, as described

[1] Bees and Wasps, p. 74. 1913.

[2] Psychic Life of Insects, p. 317. 1922.

above. One may even swing the net or otherwise disturb them or even handle them with impunity. They possess stings, but they seem not to know how to use them when taken in the fingers.[1] Thus we see that our American *Anthophora,* while gregarious, are very primitive in the scale of socialization.

The White-banded Bee, *Entechnia taurea* Say (J. C. Crawford)[2]

While the mining-bee *Anthophora abrupta,* would build only horizontally in the face of the clay bank in the bright sunlight, the species now considered, her nearest neighbor, whose nesting-habits were in general very similar, built vertical burrows in the top of the bank. Sunlight was not a factor in their choice of a site, for most of their burrows were far back in the shadow of the porch where the amount of light was much reduced.

. 5. *Anthophora abrupta.*

Fig. 6. *Anthophora raui.*

Fig. 7. *Entechnia taurea.*

These white-banded mining bees, *Entechnia taurea* (fig. 7) worked energetically through a much longer season than the *Anthophora* bees. They were out and buzzing about the holes in the clay bank as early as July 12th, 1917, and a few were still to be seen on October 3rd, although many dead

[1] Many of these bees were taken in the fingers and marked before being taken on homing flights (Journal Comp. Psychology, pp. 35-70. 1929) but they never retaliated with a sting.

[2] This identification was verified by Mr. S. A. Rohwer, who calls it *(Entechnia) Melitoma taurea.*

ones then lay about, which showed that their season was practically over, and the remaining few had not long to live.

The first of the bees were active on the clay bank (fig. 2) on July 12th; by the 16th, about twenty-five were present in a state of agitation but doing nothing definite; most of them were in a group at the extreme south end of the bank.

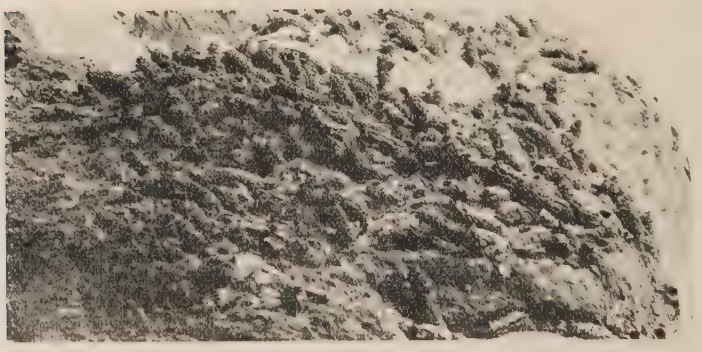

Fig. 8. A view in profile of the turrets made by *Anthophora abrupta*.

Occasionally some of them would get into the empty holes and quietly remain there, but the great majority spent their time buzzing and fussing about one another, often quarreling. One shallow burrow and its occupant attracted particular attention; the bee was within with its head to the wall and the tip of its abdomen near the orifice. This bee was the object of much conflict; often five or six bees would crowd about the opening and attempt to drag it out by main force; when one would attempt to get the inmate out, and had partially succeeded, then two or three would actually fight furiously in the doorway to get its place in the cell. They would grasp one another by the legs, and often a pair locked in combat would roll down the embankment and struggle in battle on the ground, holding a tight grip of one another's legs with their mandibles. Sometimes the one in possession

FIG. 9

FIG. 10

Fig. 9. The turrets of the white-banded bee, *Entechnia taurea* indicated by letter "E." The two arrows point to the upturned turrets of *Anthophora raui.*

Fig. 10. The upturned turrets of *Anthophora raui.* A wad of cotton is placed in the opening of some of the turrets to show their upturned position

of the burrow would come out and fight with the intruder.[1] On one occasion the occupant grabbed the leg of the intruder in its mandibles and held on so tenaciously that the bee in attempting to pull the leg away, dragged the occupant a great distance from the hole, thus giving opportunity to a bee nearby to enter and take possession of the coveted place. Often throughout the conflict the legs were gripped so fiercely in the mandibles that I thought surely they would be snipped off, but this never happened.

After capturing many of the bees, I ascertained, by the absence of pollen baskets, that they were males, and I promptly wondered if they did not crowd around certain burrows that were about to give forth members of the opposite sex. There was one hole in particular about which they crowded thus in clamorous competition, so I decided to open the burrow with my knife. The contestants, however, were not to be pushed aside; they persisted there, even though the blade nearly severed them, and excitedly buzzed about the tool; it seemed they could scent the female within, and could not be driven from the spot. Again and again I tried to penetrate the mass to remove the few little clods of dirt which hid the secret prize, but it could not be done without dismembering the bees. Another cocoon was unearthed elsewhere in the bank, however, and with a knife it was carefully opened; within was a bee, fully developed but all wet and soggy and with wings uninflated. It was in my forceps but a few seconds before a half a dozen males were clinging to it, displaying every evidence of a great eagerness to mate. The excitement continued for some minutes, when one male and this immature one succeeded in making their escape.

Since at the beginning of the season only one female was seen at work burrowing, and some twenty-five males were about, it appears that in this species, as in many other cases of the insect world, the males enjoy a priority of emergence, and await the coming of the females.

[1] I do not know whether or not they used their stings on one another; when females were taken in the fingers, they did not hesitate to use the sting freely. The pain, however, was not severe, lasting only a few minutes. In this they differed from *Anthophora abrupta*.

Following these first busy days, the population of *Entechnia taurea* seemed to disperse, for on several occasions during the remainder of July, only a few at a time were seen about the place. They, of course, were females, busily coming and going about the burrows they were rapidly digging and the clay chimneys which they were building

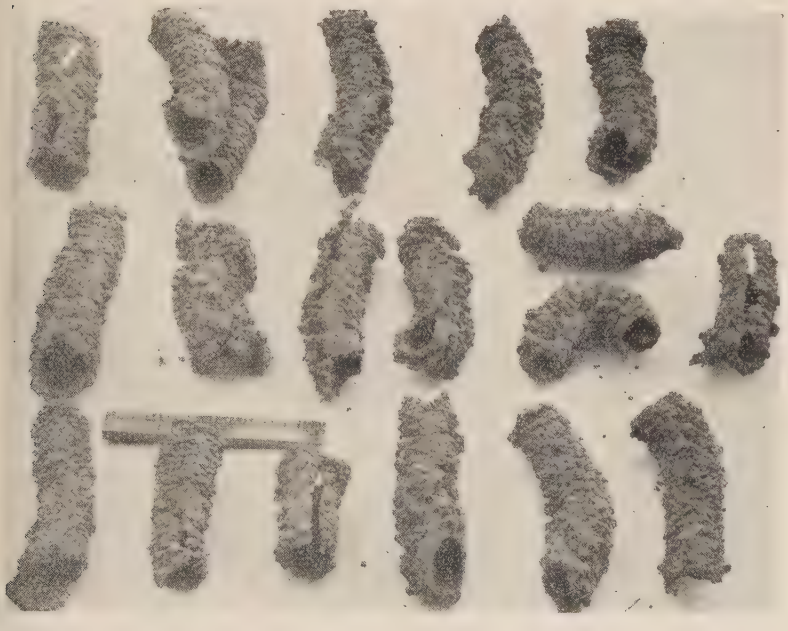

Fig. 11. A collection of turrets of *Anthophora abrupta* to show details of construction.

over them. A few males were there too. The bees were divided into two groups, one at either end of the bank, while the center which bore an abundance of old burrows of *Anthophora,* had no bees. Enormous numbers of parasites lurked about this portion, which would indicate that only those at the extreme ends had escaped their ravages. At the north end, some half dozen males were playfully buzzing about, keeping strictly to the confines of their own

neighborhood. Moreover there were then in this immediate area no females, nor were any nests in construction. This was conspicuously different from the south end, where activities were occurring, in small numbers to be sure, but further advanced, since there the males had departed and the females were nesting. This playfulness of the males at the north end seemed to be merely a repetition of the male frolics at the south end some ten days before.

A visit to the bank on August 14th showed that the females and their burrows were becoming more numerous. At the south end, the males were again in abundance, buzzing, flying, dancing about and repeating the performance of leg-pulling and leg-biting. The females were still burrowing in the top surface of the bank; none had as yet gone into its vertical face. Few of the females would work after the sun had left the bank at about noon, and the males too were most active in the sunlight.

The method of digging and building was in most of its details similar to that of *Anthophora abrupta*, previously described. The *Entechnia taurea* female carried water with which to moisten the clay before she bit off a mouthful. One mother was observed to begin her burrow at 11 a.m. She stood on her head in a vertical position, with the abdomen waving in the air, and worked the soil, often leaving the work to go for water. At 2:30 p.m. the hole went down to a considerable depth, and over its top was a little turret about three-fourths inch in length. There was much loose, wet soil about and under this turret, showing that not all of the mud carried out had gone into the tube. The bee was at work within, and every few seconds she appeared walking backwards and pushing up a pile of moist, fine-cut soil. Many turrets had beneath them a similar accumulation of clay which had been dumped out of the burrow, (fig. 9E) so that one may say that only the portions first removed go into making the chimney, and the remainder of the clay that comes out of the burrow is loosely pushed out.

One mother had been busily occupied at nest building for three hours, when suddenly a male appeared upon the scene, hovering over her. Quick as a flash she quit her work, and her precipitous haste in attempting to clean her-

self and primp (this female rubbed the powdery dust off) was really uproarously funny; but little details of appearance seemed to make no difference to him, and he urged his attentions without delay. Immediately after their separation a half minute later, she went into the hole and the male followed. Soon both came out; then they went in again as though prospecting, she leading and he following her all the time. After a few minutes, both came out, danced and fluttered about each other before her doorway for two minutes, then she went back to her work and he continued the dance for many minutes before the burrow, during all the time going no more than two feet away.

At the rear of the house on its west side was another clay embankment, of similar soil, but not protected by a porch, and neither did it receive the morning sun. No bees were burrowing there, but the area bore many plants of bindweed, with the large white morning-glory-like flowers. Here the females sought pollen, and on one autumn day, when only six blossoms were open, each flower was occupied by an idle male, while dozens of others were trying to find places. They would most persistently sit within the cup for hours at a time, and would bob up and fight away any bee that attempted to enter. All that I examined were males. The only explanation that I can think of to justify such conduct is that they were lying in wait here for the females. Yet I cannot have full confidence in even this supposition, for on a few occasions I saw these dogs-in-the-manger fight away even the females who came in earnest quest of pollen. The same leg-pulling behavior that was seen on the clay bank was practiced within the blossoms whenever a second male attempted to usurp the place of the first. When the males entered the flowers they did so head first and then turned themselves around and faced the outside, so they could watch what was going on out in the world. It will be noted that while the length of life of adult males of the two species of Anthophora bees is only a few days, in *E. taurea* the males live all summer.

When the females came in from the fields pollen-laden, it appeared at first that they carried the pollen under the abdomen, with great masses bulging out at the sides and

back. In reality, however, the pollen-baskets were overflowing, and masses of pollen adhered to the underside of the body, while the legs were held close to the body, probably holding the abdominal masses in place, with the result that the little bee had the appearance of being very fully laden indeed.

Up to August 20th, most of the white-banded bees were still making their burrows and chimneys on the surface plane, and only about ten per cent of them were beginning to dig into the vertical face of the bank. In the case of this species, probably as soon as one nest was completed another was begun.

Most of the turrets made by this species (figs. 9E and 13) had a longitudinal split extending almost the full length of the upper side along its center. The purpose of this, as well as the purpose of the whole chimney, has often puzzled me. I have wondered whether the cause of this was mechanical or psychological, but after having observed the method of making the chimney, I have concluded that the opening along the middle of the chimney may be accounted for as mechanical. The bee backs out with a large ball of mud under her throat; with the forelegs she divides this load in half and passes one portion backward under the body until it reaches the tip of the abdomen. This is applied to the edge of the turret, commencing at the bottom and working toward the top. This amount of wet clay is usually about enough to make half a ring. Then likewise the second half is passed beneath the body to the rear legs, the bee begins at the bottom again, joins this wet mass to the end of the first half of the ring and works upward in the opposite direction, perhaps with the intention of completing the ring, but rarely doing so. Since the second portion does not quite reach the first, there is a discrepancy, and the result is that layer after layer of this leaves an open groove on the top of the turret. It is possible that this is done purposely, and that the insect could just as easily carry out a little more mud or stretch what she has so as to complete the circle if she wished to do so. It may be that it is of advantage to build the nest so that it will admit the light, and this peculiarity of construction has become a habit. It is very pretty

Fig. 12. (Above) A clump of earth containing cells of *Anthophora abrupta* (¾ natural size).

Fig. 13. (Below) The turrets of the white-banded bee *Entechnia taurea* (slightly enlarged).

to see the bee's abdomen extending just beyond the last ring of the turret, and then applying the two portions of mud deftly to the last layer. She cannot see what she is doing, since during this work her head is always inside the chimney.

Fig. 14. An uprooted tree, both sides of which contained nests of *Entechnia taurea*.

Since I wished not to demolish the bank, I opened only a few burrows. The first consisted of a gallery one inch in length, terminating in a pocket in which were two neat, thimble-shaped cells.[1] One of these was sealed; when opened, it was found to be crammed full of white pollen (or perhaps bee-bread, since part of it was moist and might have been mixed with nectar or water), and on a dry portion of the mass and securely attached to it was the elongated egg. The lower cell contained the same. The lower part of the mass of bee-bread was very moist and soggy, while the

[1] These cells were not made by merely partitioning the tunnel, but each was a solid mud cup built inside the burrow and snugly fitted into it. When these nests were opened the surrounding earth could merely be picked off leaving a complete cup as illustrated in Fig. 15.

upper part was dry, powdery pollen. There were also many drops of moisture condensed on the walls of this cell. Whether the pollen had been put in dry, and the moisture that we found in the cell was due to nectar or water which the mother may have added, or whether the pollen was moist and the moisture which I found upon opening the cell was that which had come out of the pollen and condensed on the walls, is matter for conjecture.

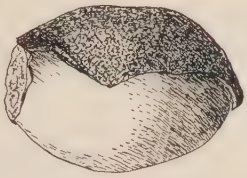

Fig. 15. The brood cup of *E. taurea,* with the mud wall cut away to show the intact papery lining.

Another nest was opened which had a three-and-one-half inch gallery leading down to the cell. This cell was half filled with pollen, and the bee itself was within, with her pollen baskets full to overflowing. The nest was obviously far from complete. These bees do not seal the mouth of the turret; neither do they seal the burrow at the surface of the ground, but leave it open its full length. The cells at the bottom are sealed securely enough to afford sufficient protection when they are hidden within the tunnels chiseled out of the hard clay. Sometimes one does find one of these turrets sealed, but this work is done by a *Trypoxylon* wasp which takes possession of the place for her own nest.

These white-banded bees varnished the interior of their brood-cups with some waterproof substance, as did the two species of *Anthophora;* but these supplied an added protection to the young bees, in the form of a thin, papery wall which completely lined the cells. While it is brittle, it is strong enough that one may pick away the mud from the outside and leave this lining intact, as shown in fig. 15. At first I thought that this lining had been placed there by the mother, but since those cells in which the eggs had failed to hatch did not have this lining, it seemed reasonable to

attribute it to the work of the larvae. An examination of this material under the microscope does not show a structure of spun silk; hence it is probably made of the contents of the alimentary tract, which are completely emptied at the time of pupation. It is a known fact that in certain aculeate Hymenoptera, the excrementary material of the larva is retained until pupation time when it is emptied and fashioned into a cocoon. Here in the white-banded bee is a similar condition, with the slight change of using the material for caulking purposes instead of cocooning.

That *Entechnia taurea* attains gregariousness is due just as much to the fact that the clay bank is protected as to their community instincts. In 1917 I noticed a sickly colony in a clay bluff about one-quarter mile south of the bank. These burrows went horizontally into the bank at a road, and had no protection from the weather. Only three turrets and their builders were seen. This colony did not become established, and in 1918 no progeny were there. In 1918, two turrets were found at the side of a foot-path on a hill-top in the shade of an old oak. In the same season, the dirt about the base of an uprooted tree at a point about fifteen miles distant from the bank had twelve turrets of this species. The knotty roots served as protection from the weather, so the colony there was able to grow. The fact that the bees of the Wickes clay bank became colonized under the protection of the porch is no mere accident, but the following notes made at various distant localities, show that the habit of seeking protected places is general for this species, or, to put the explanation in other words, those bees which nest in sheltered areas grow into colonies and those which do not, either they or their progeny fall victim to the elements, landslides, etc.

At Keys Summit, Mo., a clay embankment by the roadside and facing the western sun, had forty or fifty of these turret-topped nests, penetrating the slope horizontally, scattered along the slope for about a hundred and fifty yards. This bank was about ten feet high, and some vegetation and a few trees were growing there whose roots held the earth firm and made protecting niches in the bank. All of these nests were found in the protected spots, and none

in the exposed portions. One can readily see how landslides or rain would demolish the work of these little builders, and do damage to their tunnels as well. Three small colonies were seen, also, in roadside banks in situations similar to the above except that the soil was crumbly and exposed. Much of their work has been lost; they did not become established in these exposed sites. Others were seen at Wesco, one hundred twenty miles southwest of St. Louis. Some were in banks, others in level ground, and in three different places they had chosen for their home-site the soil in the roots of some trees which had been torn up by a tornado three years previously. Here again they enjoyed the protection of the roots, and throve. One of them (fig. 14) had twenty-five nests on one side of the base of the upturned tree, and thirty on the opposite side.

The colony of bees during the five years, had decreased in size. In 1922 about forty members were building and two-thirds of them were far back on top of the clay bank where the darkness was indeed conspicuous; the turrets were pointing in every direction. During this same period its neighbor *Anthophora abrupta* had reached great proportions. The causes for the rise of one species and the decline of the other, are fully discussed in the St. Louis Academy of Science paper already referred to.

A DISCUSSION OF HUMAN AND INSECT SOCIETIES

By Milton F. Crowell

In considering insect and human societies together we face several problems. 1. What is a society? 2. By what methods do insects and men solve the problems of a social life? 3. Is there any reason to believe that, if human and insect societies differ, they may, eventually, evolve into the same type?

To define a society in terms that will permit the inclusion of both insects and men, and exclude animals not usually regarded as social, is well-nigh impossible, but the following definition is suggested: A society is a group of organisms of the same species in which specific survival is dependent upon association in a group; the characteristics of the group as a unit differ from those arising as a mere sum of its individual parts; the functions of the group necessary for its existence, therefore necessary for the survival of the species, are carried out by a division of labor among the individuals of the group; the successful carrying out of these functions is dependent upon the ability of the group to exploit a given area, or trophoporic field. As a corollary to this definition, implied, but not specifically stated in it, a society must be self-perpetuating.

The problems of social life are contained in definition of society, and they over-lap.

1. The creation of the group.
2. The maintenance of the group.
   a. The re-creation of the group.
   b. Provision of food and shelter.
      (1). Exploitation of the trophoporic field.
   c. Defence of the group.

3. The perpetration of the group.

   a. Dependent upon the effectiveness with which the group is maintained.

In neither man nor insects can we speak of the creation of the group in the strict sense. The groups, or societies, are being constantly re-created, or perpetuated. In the insect society perhaps, we come nearer to society creation, for, regarding each colony as a separate society, it is begun, in the termites, when a male and female start a new nest; in the ants, when, by various methods, a fertilized female succeeds in founding a colony, and in the bees, when a swarm occurs. But in most instances, even here, there is a mixing of colonies, since in the nuptial flights of social insects a certain amount of cross-breeding takes place, i.e., between males and females of different colonies, so we can, to a certain extent, regard insect society as being much broader than the single colony.

The problems of maintenance and perpetuation are, to a great degree, the same. In order to provide food and shelter there must be a sufficient number of individuals to carry out the work of provision. In order to have a sufficient number of individuals to provide for the group, food and shelter must be efficiently supplied. Since both the production of offspring and the provision of food are necessary to maintain a society it is fruitless to discuss which is the more important.

In reproduction we find that there are two general methods found in the various types of societies. Both are effective, and each is apparently the best for the society in which it is found. There may be developed a special machinery for reproduction, i.e., a reproductive caste, whose contribution to the community is solely offspring. Or we may have no special reproductive caste, but the production of a few offspring by each, (or as is actually the case, by most), of the group units. (Group units, in speaking of reproduction in higher animals, are obviously not individuals, but are composed of two individuals of the opposite sex.)

The first type produces numerous large families which,

to a great extent, form separate homogeneous societies. The second type produces a looser heterogeneous society of which separate families are but the basic units. The insect society depends upon large numbers of offspring produced by individual females; the human society depends upon a large number of females producing few offsprings. This distinction is primarily biological, hence fundamental.

There are two ways in which large numbers of offspring can be produced by a single female. One is by the over-development of the ovaries, and the laying of a great number of eggs. (Queen of *Termes bellicosus;* "she has laid an egg every three minutes for the past four years," Wheeler, 1928, a total of almost a million)[1]; the queen honey-bee, *Apis mellifica,* lays about 3500 eggs a day for several weeks at the height of the breeding season, Langstroth, 1909. The second is by polyembryony, or the development of several offspring from the same egg. This is found in a number of the higher hymenoptera. *(Aphelopus theliae,* whose single egg produces 40-60 offspring, according to Kornhauser, 1919; *Copsidosoma gelechiae, Paracopidosomopis floridanus, Platygaster sp.,* the first with over 300, the second averaging over 1000, and the last 5-36 offspring, which Patterson, 1919, believes may develop from single eggs.)

The method of foetal development in the placental mammals makes impossible the production of offspring in great numbers by a single female. Both the limits of space, (the size of the uterus,) and the limits of time, (length of life compared with time necessary for foetal development), place decided limits to the possible number of offspring. So it seems clear that, basically, human and insect societies can never be physically homologous.

In solving the problems of maintenance by the provision of food and sheiter both human and insect societies exploit a trophoporic field. This field is the actual territorial area

[1]E. Hegh, 1922, in "Les Termites," says of *T. bellicosus,* "qui, d'apres Smeathman et Escherich, serait d'au moins trente mille par jour, soit dix millions par an et cent millions pour la duree probable de la vie de la reine." I do not understand this disagreement of authorities, but an egg every three minutes is 20 an hour, and thus only 480 a day. In either case, a large number of eggs is laid.

which supplies the raw materials of food and shelter building. While there is a fundamental difference between the methods used by men and insects to re-create the group, the methods used by each to exploit the trophoporic field do not differ fundamentally. There are two methods used: the actual collection from the field of the materials needed (in the insects by foraging for what can be found), by development, as the growth of fungi and the "domestication" of aphids by ants; in man, foraging, (not common), and development, (farming, mining, etc.), and the taking by force of the materials collected by other groups. The second method is dependent upon the first, and is essentially non-social when it means the exploitation of parts of a society by other parts. Of course, one society may legitimately become a part of the trophoporic field of another, as the keeping of bees by man, or the eating of a library by termites. (There is no reason, from a termite point of view, for respecting the possessions of man). And in each society, human and insect, the exploitation of the trophoporic field is possible only by labor on the part of the individuals of the society.

Since the many activities necessary for efficient production can be carried out best by a specialization for particular tasks among the members of a society we find that there is a division of labor developed by both insects and men. The first most fundamental division of labor is, of course, the development of sex. This is found in both groups. But, as pointed out before, the insects have developed a special caste that does nothing but reproduce, while man has not. In the exploitation of the trophoric field, too, the insects have developed a caste, which has, to a great degree, lost its ability to reproduce, the worker caste. This sterile caste does all of the labor necessary for producing food, building the nest (except in the case of some insects where the primal sexual pair, or a single fertilized female, initiates the work of nest building), caring for the reproductive caste (whose children they are), and caring for the new brood (their brothers and sisters). This division of labor has brought about an actual structural difference between the reproductive and worker castes,

and in many instances, specialization to tasks performed has caused the development of structural differences among the workers themselves. This is termed polymorphism.

The differentiation of sexes is a form of polymorphism, and it would be admissible to speak of a male and a female caste, but that is as far as caste and polymorphism in any way homologous to that of insects has been carried in man. Since in a society which is based upon a grouping of small families[1] the production of offspring falls upon all, it follows that in order to maintain and perpetuate the society there cannot be present in it a large percentage of sterile individuals. Also, in that type of society, there cannot be any great degree of polymorphism, for the forming of numerous families implies the necessity for a wide range of possibility to mate. There is also the implication that any member of this society shall be able to carry on any function of the group. This may not seem evident at first glance, but human society is a conglomeration of numerous small societies, i. e., families, and because of the type of foetal development in the placental animals, and the period after birth during which the young are dependent, the maintenance of the family falls upon the adult members, and they cannot become so specialized that they cannot perform any one of the functions necessary for maintenance. Hence, if they must remain generalized with regard to the family, they must remain generalized with regard to society, which is but a group of families. (This refers only to morphological specialization). Therefore it follows that the division of labor in the exploitation of the trophoporic field is, in man, brought about in a manner fundamentally different from that of the insects. It is not a specialization, in the biological sense, but is a development of one or more generalized abilities possessed in varying degrees by all members of the group. Therefore the laboring class, the

[1]The human family, no matter how large it may be, is, of course, a small one. This is evident when we consider that, at the utmost, one woman could bear only about 30 children, while a family of social insects may number well over a million individuals all produced by one female.

capitalistic class, and the castes of India, are not homologous to the castes of insects.

There are at least two classes of human beings that might be considered as being somewhat analogues to the workers of the termites, or higher ants: the priests of many religions, and the eunuchs of Eastern countries. The priest, in so far as he represents a sterile class, sterile through voluntary celibacy, is an example of a non-reproducing individual laboring for the good of the organization to which he belongs. (Not necessarily for the good of society). The eunuch is functionally sterile, and thus approaches nearer an analogy to the insect worker. And if the interpretation of polymorphism of the social insects which holds that the differentiation of the castes is caused by giving different food to the larvae that are destined to develop into different forms be correct, the difference between the ennuch of the harem and the worker insect becomes still less. Both are then products of a deliberate castration, whether it be a reasoning and purposive act, or a blind instinctive reaction governed by the needs of the insect colony.

But the likness of the priest and eunuch to the worker insect is more apparent than real. Although the priest may be socially sterile he is not functionally so, and he is not morphologically set apart for the performance of certain duties. And while the eunuch is, of course, sterile, his sterility is not the result of the necessity of society to have a group of workers who will have their labors uninterrupted by the functions of reproduction, but is to prevent his having sexual connection with the women of his master's household.

While the exploitation of the trophoporic field by a society requires many laborers, and the problem has been solved in man and in insects by two methods of reproduction (a great number of offspring produced by one female, and a great number of females each producing a few offspring) man has added a second method of producing workers, that is by the invention and development of machinery. The machine either greatly increases the efficiency of the individual worker, or greatly multiplies him by doing what many men would be required to do. In being

sterile, (physiologically), and in being able to accomplish only a special task, the machine is nearer to the insect worker than is any class of men. Genetically, of course, it is not even analogous to the insect. The introduction of the machine, on the one hand, and the development of the highly specialized worker on the other, has forced both men and insects to face the problem of what to do with individuals that the machine, or the accomplishment of a special function, has deprived of work. The insects have solved it. When the work of the specialists is done they are slaughtered. When the introduction of a new machine deprives a number of men of work . . . the problem has not been solved.

Besides maintenance by the exploitation of the trophoporic field the society must be maintained against destruction by the elements, broadly, climate, and destruction by other societies, sub-groups of itself, (nations, different colonies), and against the attacks of other organisms, (beasts of prey, disease germs, etc.).

The primary method of defense is flight; next comes the building of shelters. The ants and termites construct caverns, the wasps build houses, i. e., paper nests, etc. Man's shelters differ little fundamentally from those of insects. Advantage is taken of natural shelters, caves, comparable to the use of hollow trees by bees, or houses are built, comparable to wasps' nests. Shelters are employed as a means of defense against all types of attack.

A more active method found in both insect and men is the development of special classes for defensive purposes, "soldiers" in the ants, termites; soldiers, policemen, etc., in human society. There is the same distinction between the human soldier and the insect soldier that is found between the human worker and the insect worker. One is a specialized organism, the other is a generalized organism in which certain abilities are specialized. An insect soldier can be only a soldier, really a specialized worker, but a human soldier may be a soldier temporarily, and is not forced by his morphology to be one whether or no.

The last problem of a society, and perhaps the first, perpetuation has already been discussed. Its successful ac-

complishment depends entirely upon the success with which the group is maintained.

The possibility of the insect and human types of society becoming identical was the third question asked at the beginning. The two societies face the same problems, and in some instances their methods of solution are the same. But in the development of the means by which these methods are carried out the two societies are different. In the discussion of the methods by which the two societies are re-created, and the workers developed, the points of difference were stated. And there it was brought out that the two types of society are not homologous. The fundamental difference, and one which is insurmountable, is the difference between the Hexapods and the Placentalia.

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A JURASSIC NEUROPTERAN FROM THE LITHOGRAPHIC LIMESTONE OF BAVARIA.[1]

By F. M. Carpenter

In the Hagen collection of fossil insects at the Museum of Comparative Zoölogy there are a number of Neuropteroides from the lithographic limestone of Solenhofen, Bavaria. Most of these insects were adequately described by Hagen in his several papers on the neuropteroid fauna of this formation, but some of them were dismissed with only a few words or were not described at all, so that their exact affinities have been uncertain. Among these incompletely described fossils there is one which is especially striking, because of its excellent preservation and its affinities with certain recent genera. Since Mesozoic Neuroptera are very rare, it seems advisable to describe this fossil with the completeness it deserves.

The insect is a true Neuropteran (Planipennia) and is the specimen to which Hagen applied the name *Nymphes fossilis* in his *Neuropteren aus dem lithographischen Schiefer in Bayern* (1862). Except for the mere statement that the fossil was an excellent one, no description or figure was given, so that Hagen's name for the insect has no standing. Handlirsch did not examine this specimen during the preparation of his comprehensive account of fossil insects, and was obliged to ignore it. The other Neuroptera of the lithographic limestone have been treated by several authors in general accounts of the Solenhofen insects. Eighteen recognizable species have been described, although it is probable that some of these are synonymous. Handlirsch's division of the species into families is largely artificial and unsatisfactory, but a dependable classification can be made

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only after a study of the type specimens. It is quite obvious, however, that insects related to the recent *Hemerobiidae* and *Myrmeliontidae* are present, as well as others more remote from these families. One of the genera, *Nymphites* Hasse (1890,) seems to be closely related to the recent Australian genus *Nymphes*, as observed by Hasse. The Jurassic genus differs from *Nymphes* by the possession of a branched media in the fore wing and a much smaller number of cross-veins. A second genus, *Sialium* Westwood (1854), was based upon a species apparently somewhat similar to *Nymphites*, but the type specimen is so poorly preserved that its exact affinities cannot be determined.[1] Hagen's "Nymphes fossilis", although undoubtedly belonging to a new genus, is so closely related to *Nymphites* that I can see no reason to exclude it from the family *Nymphitidae*.

Family *Nymphitidae*.

Mesonymphes, new genus.

Allied to *Nymphes* and *Nymphites*. Wings slender, pointed, with a number of cross-veins in the costal space and in the subcostal area, between R1 and Sc. Sc close to R1; R1 bent downward distally; Rs with 13 branches in the fore wing, and 11 in the hind wing; media joined to the stem of the radius a little basad of the origin of Rs; M branched in the fore wing, the branches diverging close to the base of the wing; M unbranched in the hind wing; Cu1 without a basal branch; Cu2 a well-developed vein, sending a large series of short terminal branches to the hind margin of the wing; 3 anal veins in the fore wing. The hind wing has a narrower costal space, a smaller anal area, and is somewhat shorter than the fore wing. Cross-veins much less numerous than in *Nymphes*.

Genotype: *Mesonymphes hageni*, n. sp.

(Figure 1.)

Length of fore wing (estimated), 4.0 cm.; hind wing, 3.6 cm. Width of fore wing, 1.0 cm.; hind wing, 9 cm. Anterior

[1] Scudder even placed it within the Blattidae (Mem. Bost. Soc. N. H. 3:472, 1886).

margin of wing straight or nearly so, posterior margin regularly convex, the wing being broadest at about the middle; the costal space is much broader distally, so that the termination of R1 is very remote from the apex of the wing; area between Sc and R1 with 4 or 5 cross-veins; R1 distinctly curved backward at its distal end; Rs and M diverging from R close together; space between R1 and Rs with less than 10 cross-veins; between the basal branches

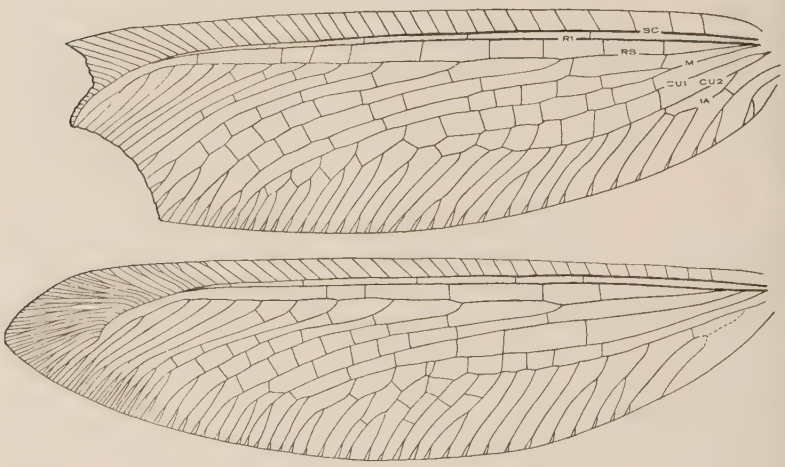

Fig. 1 Venation of fore end hind wings of *Mesonymphes hageni,* n. sp. Sc, subcosta; Rl, radius proper; Rs, radial sector; M, media; Cul and Cu2, branches of cubitus; 1A, first anal.

of Rs there are numerous cross-veins, but there are apparently none at all between the distal branches; Cu1 long and straight, with seven irregular distal branches; Cu2 is much more strongly developed, with eleven branches; 1A forked in both wings; cross-veins present between Cu1 and Cu2. The specimen has the left fore and hind wings well apart; the right wings are folded together, so that the veins are indistinguishable. The body is slender, being 30 mm. long, and 3 mm. wide; no details of the head are preserved.

Holotype: no. 1999 Museum of Comparative Zoölogy. On the back of this specimen, in German script and in Hagen's

characteristic writing: "Nymphes verwandt, herrlich!", and also printed on a label, which has been pasted to the rock: "Nymphes fossilis Hagen. Paleont. X. P. 108 No. 36. Type. Solenhofen, Dr. Krantz."

The generic affinities of *Mesonymphes* are quite obvious. From *Nymphites* it differs by the possession of an unbranched media in the fore wing, by a more pronounced development of the costal space towards the apex of the wing, by the more specialized termination of R1, and especially in the degree of development of Cu2. In the structure of the first three of these features the venation approaches that of *Nymphes* itself, but the cubitus is decidedly different. Cu1 of *Mesonymphes* sends off only seven branches while Cu2 gives rise to eleven; in *Nymphes* there are 8 branches leading from Cu1, and only 5 from Cu2. There is a close resemblance of *Mesonymphes* to the Myiodactylid genus *Osmylops*, which inhabits parts of Australia.[1] The costal area is much broader in the recent genus and the terminations of Sc and R1 are somewhat different, but the structure of the cubitus in the fore wing is quite the same in both genera. Martynov has described a related Neuropteran from the Jurassic beds of Turkestan (1927), but this fossil has closer affinities with the *Hemerobiidae* than with the *Nymphitidae*.

The modern aspect of *Mesonymphes* is of unusual interest. If a Neuropteran with the venational characteristics of *Mesonymphes* were found in the tropics at the present time, it would probably not arouse much comment. The only feature of this insect which is more primitive than that of *Nymphes* is the small number of cross-veins. For although Martynov in his description of the Turkestan form claims that the original ancestral condition of the Myrmeleontid types was characterized by a larger number of cross-veins, which have decreased from the Jurassic to the present, this conception is contrary to all the evidence that has been accumulated on the evolution of the order.

[1] I do not accept Tillyard's interpretation of the venation of this genus, as explained in his "Insects of Australia and New Zealand" (p. 321, and fig. U16). The vein which he has labeled M3+4, being strongly *convex*, is Cu1, and his Cu1, being strongly *concave*, is Cu2.

Tillyard, in his Panorpoid Complex, concluded from a study of recent and fossil Neuroptera that the ancestral and primitive forms of the order possessed only a few, widely-spaced cross-veins, and nothing has subsequently been found to refute his view. This small number of cross-veins is the only characteristic of *Nesonymphes* which is not found in *Nymphes* or closely related genera now existing in the tropics.

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ECOLOGICAL OBSERVATIONS UPON THE MYRMECOCOLES OF *FORMICA ULKEI* EMERY, ESPECIALLY *LEPTINUS TESTACEUS* MUELLER[1]

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In the autumn of 1928 certain observations were made upon the blind beetle, *Leptinus testaceus* Müll. in the Chicago area ,which was found associated with other species of Coleoptera in the nests of the mound-building ant, *Formica ulkei* Emery. Some of these data are presented at this time.

The Ecological Status of *Leptinus testaceus*.

Leng (1920) gives the general distribution of this species as Europe, Iowa, Ohio, Pennsylvania, District of Columbia, and British Columbia, and Brendel (1887) lists *testaceus* from the vicinity of Peoria, Illinois. Its presence in the Chicago area is attested to by only two previous records, e.g., Longley (1905) found a solitary specimen in a mouse nest at Clarke, Indiana, and Blatchley (1910) records the species from Lake County, Indiana, finding it from March 11 to December 1, when it probably hibernates in the imaginal state.

This leptinid apparently has a wide range of hosts, being found upon, or in the nest of, wood-mice, field-mice, moles,

[1]The term "Myrmecocoles" is used here, rather than "Myrmecophiles", not as an additional burden to the terminology. The usage of the former is broader, embracing all of those species occurring in the nests of ants, and less definite, since the degree of association between occupant and host is not known with exactness in many instances, and consequently reserves for the latter term species where an intimate relationship is known to exist.

shrews, rats and small mammals in general, especially the rodents and insectivores (LeConte, after Brendel, 1866; Riley, 1889; Schwarz, 1890; Dury, 1892; Kellogg, 1914, and Jeannel, 1922); in the nests of birds (Imms, 1924); in the nests of Hymenoptera, viz. Vespidae, *Bombus*, and *Formica* (Jeannel, l.c., and Imms, l.c.). Imms (l.c.) has even mentioned its occurrence in rotton wood, and it was taken under "chalk flints" by Hardy (1848).

The exact relation of this species to its several hosts is not definitely known. Its status has been variously placed as that of an ectoparasite feeding upon the hair or secretions of small host mammals; as that of a scavanger, living on the nest refuse; as a tolerated guest; or as one of those species exhibiting phoresy, and the literature is partially covered and the questions involved discussed by Kellogg, 1914, Rüschkamp, 1914, and Jeannel, 1922. Dury and Blatchley believe this leptinid to be a guest, possibly even feeding upon mites and fleas associated with *testaceus* in mammal nests. The presence of the species in decaying wood may indicate ability to live a more active life, or may be an accidental occurrence. On the other hand, *testaceus* may exhibit phoresy. This uncommon phenomenon has been discussed by a number of investigators, among which may be mentioned the account of Lesne in 1896, Rüschkamp, l.c., Banks, 1911, and Wheeler, 1919.

If *testaceus* exhibits phoresy, the species may live in the nests of bees, feeding upon honey and pollen, and using small mammals, such as field-mice, for transportation from one nest of bees to another. *Testaceus* is well-known as an inhabitant of the nests of bumble-bees, e.g., the work of Gorham in 1869; and Wheeler, 1923, p. 113, says of these bees that their colonies are an annual occurrence. The fecundated queen overwinters and in the spring chooses a small cavity in the ground or in a log, *preferably the abandoned nest of a mouse,* to line with grass or other materials at hand and so start the incipient colony. It is an interesting possibility that *testaceus* may live as a guest in the nests of Hymenoptera, and exhibit phoresy as the occasion arises.

It is even possible that this phoresy, if it exists, is a stage in parasitism and the blind condition of the beetles would

strengthen this view, especially since it has a relative *(Leptinillus validus)* with greatly reduced eyes. Another related species *(Leptinillus aplodontiae)* is said to leave its rodent host when the latter is killed, and as soon as the body begins to cool (Ferris, 1918), which may indicate some degree of parasitic adjustment. All of these leptinids have been shown to be closely related to the beaver parasites, Platypsyllidae, (Horn. 1882; Riley, 1889). However, they are also allied rather closely to the Silphidae morphologically (LeConte and Horn, 1883; Sharp and Muir, 1912; Imms, loc. cit.), a family which numbers scavengers, as well as saprovores and carnivores.

The various views that have been held are not necessarily mutually exclusive, and it is possible that the Leptinidae exhibit a facultative parasitism which would explain many of the differing accounts in the literature, and bring into agreement the finding of *testaceus* in habitats suggesting phoresy, a guest relationship, an actual ectoparasitism, a scavenger existence, or a chance occurrence.

Leptinus testaceus and other Coleoptera in nests of *Formica ulkei.*

On October 6, 1928, a trip was made to Palos Park, Illinois in search of Pselaphidae. Palos is some thirty miles south-west of Chicago in the glaciated section of the Chicago area and is characterized by an oak, elm, hickory subclimax forest in the upland forest sere of this area (Park, 1929 a, b). A portion of the Palos sector is inhabited by the mound-building ant, *Formica ulkei* Emery. The *ulkei* community is rather extensive, especially in the more open clearings of the forest and along the forest margins. The ant has been little studied in nature (Wheeler, 1926). Burrill and Smith (1918) record the species from Cedarsburg, Wisconsin, and in a later paper (1919) mention the finding of a larva of the chrysomelid, *Coscinoptera dominicana* (Fab.) in an *ulkei* nest. Recently, Holmquist (1926, 1928 a, b) has given the most complete account of this ant in the Chicago area, and a note upon a guest ant associated with

ulkei colonies at Palos has been published (Park, Thomas, 1929).

Formica ulkei colonies are also established at Palatine, Illinois, some thirty miles north-west of Chicago under the same general ecological conditions. The Palatine colonies have not been as thoroughly studied for myrmecocoles as those at Palos, this latter section having been visited repeatedly.

A number of species of insects have been taken from the *ulkei* colonies. These species have been determined as follows,[1] and the locality records given in order to supplement as much as possible the account of Holmquist (1928 a, pp. 83-4):

TABLE I. Myrmecocoles of *Formica ulkei* Emery.

HOMOPTERA

Cicadellidae

1. A nymph taken at Palos, August 4, 1929, in the lower dome galleries.

NEUROPTERA

2. A neuropterous larva, very similar to the larvae of the Chrysopidae, taken in a lower gallery at Palos, August 4, 1929. It may have been brought in by the ants, or it may have wandered in, either by chance or to feed upon aphids.

DIPTERA

Syrphidae

3. *Microdon*, sp. The larvae of *Microdon* were usually present in the nest, both in Palatine and at Palos, and were present in certain nests in great abundance on October 6, 1928, at Palos, especially in the less superficial galleries.

[1]I am greatly in debt to my friends, Mr. W. J. Gerhard and Mr. Emil Liljeblad, of the Field Museum of Natural History, for their care in determining and rechecking the material collected from the *ulkei* nests.

COLEOPTERA

Carabidae

4. *Tachyura incurva* (Say) Abundant. Palos: October 6 and 13, 1928; April 4 and 12, August 9 and 16, 1929. Palatine: August 6, 1929. It is interesting to note that this species has also been taken in the nests of the related host, *Formica exsectoides* (Ulke, 1890; Schwarz, 1890).

5. Two small carabid larvae were taken from the lower dome galleries, one at Palos (August 16, 1929) and one at Palatine (August 6, 1929).

Staphylinidae

6. *Megastilicus formicarius* Casey. Palos: August 4, 1929. It is interesting to note a further parallel in the myrmecocoles of *ulkei* and *exsectoides*, this staphylinid being reported from nests of the latter by Schwarz (1889).

7. *Atheta polita* Melsh. This species of the Myrmedoniini was abundant on October 6, 1928, in the dome galleries and entrances of a weak colony at Palos. This species has also been recorded from the galleries of *Reticulitermes flavipes* by Park (1929 c), and Ulke (1890) mentioned finding staphylinids allied to *Myrmedonia* in numbers in the nest of a species of *Formica*.

Leptinidæ

8. *Leptinus testaceus* Müll. Abundant in a weak colony of *ulkei* at Palos, October 6, 1928.

Pselaphndæ

9. *Batrisodes globosus* (Lec.) October 6 and 13, 1928, at Palos. In numbers on the former date.

10. *B. denticollis* Casey. Abundant at Palos on October 6, 1928; April 4 and 12, and August 4, 1929.

11. *B.* species. Palos on October 6, 1928.

Cucujidæ

12. *Cathartus advena* (Waltl.) At Palos on October 6, 1928. Possibly a chance occurrence or had penetrated the colony for hibernation.

Elateridæ

13. *Melanotus communis* (Gyll.) A single adult which was still very soft and pale from pupation, taken from a nest at Palatine on August 6, 1929.

Scarabæidæ

14. *Phyllophaga* species. Larvae, pupae and imagos taken from the Palos nests on October 6, 1928. Rather abundant.

15. *P. horni* Smith. One male. In lower dome galleries as above.

On October 6, 1928, thirteen *Leptinus testaceus* Müll. were taken from the upper galleries of a weak colony of *Formica ulkei* Emery. The mound was beginning to be overgrown with grasses and measured only eight inches high and some two feet in diameter. With the leptinids were taken fifty-six *Batrisodes* and twenty *Tachyura*.

Since *testaceus* is exceptional in the mounds of ants and is not reported from those of *ulkei*, it was sought repeatedly but others were not seen. The original lot was carried to the laboratory with other myrmecocoles for study, and the following points were learned as to the ecology of these species:

Enemies

Leptinus testaceus Müll. was isolated in a petri dish nest and thirteen workers, both major and minor, of *Formica ulkei* were introduced. This group was maintained for six days, the ants being fed on sugar water. During this time the beetles were not molested by the worker ants. The latter passed near or over the leptinids frequently without being visibly stimulated beyond a momentary pause in their walk, or an occasional investigatory movement of their antennae.

Conversely, when a *Leptinus* came into contact with an *ulkei* worker it usually crouched to the substratum, remaining motionless, and seldom ran away.

Similarly, the leptinids were apparently not molested by the pselaphids *(Batrisodes globosus* and *B. denticollis),* and *vice versa,* nor were the pselaphids attacked by the ants.

In another series of observations, leptinids were isolated with the carabid, *Tachyura incurva.* In one petri dish, out of three used, the leptinids were unmolested. In the other two nests, each having one *Leptinus* and three *Tachyura,* the *Leptinus* were completely devoured within twenty-four hours save for the meso- and meta-sterna and the elytra. Further details on the carnivorous behavior of these carabids will be given later, however it is interesting to note that when a leptinid was met by *Tachyura* in the laboratory nests it frequently darted out of the latter's path.

Food

Just what the food of *testaceus* consists of has been generally guessed at and in view of the controversial nature of its status with its many hosts, some knowledge of its feeding habits should be of interest.

A simple leptinid was placed in each of six petri dish nests and given no food by the experimenter for two days. Obviously, during this time it may very well have caught and devoured small organisms in the soil taken from the *ulkei* nests placed in the dishes, which could not be readily removed, e.g., small acarinids (Gamasoidea?).

At the end of two days, viz., the second night, a depressed slide full of sugar syrup was placed in each dish. Two of the leptinids were observed to halt at the slide. These two lowered the head and prothorax and after tapping about with their antennae, moistened their palpae and mandibles in the solution. The other two either went around the syrup, or turned back on their path. It is possible then, that *testaceus* will feed on occasion on sugar syrup. Mere moisture was certainly not at a premium in the petri nests as one section of the soil was kept saturated with water.

Formica ulkei workers, it may be added, readily took up the sugar syrup and subsequently could be seen regurgitating to other workers. The pselaphids, *Batrisodes*, were not observed to feed on the sugar solution and often walked through, or were caught in, the syrup without being seen to take any with their mouth parts.

In view of these data, it is possible that *testaceus*, under the proper conditions, feeds on the honey in the nests of bumble-bees, and since its food habits are compatiable with this view, it may exhibit phoresy, being carried about by mammals from one nest of bees to another, and consequently being taken in their nests as well. This is not to say that *testaceus* could not exhibit carnivorous or omnivorous behavior, nor that it could not live as both an ectoparasite and a guest, under suitable conditions.

The occurrence of *Tachyura incurva* (Say) in the nests of ants, especially *Formica exsectoides*, a host ant related rather closely to *F. ulkei*, has been noted by Ulke (1890), and Schwarz (1890), and its general distribution under bark and on the floor of forests is commented upon later. Despite the abundance of this species, little is known of its behavior.

Incurva apparently shows some periodicity in its appearance with *Formica ulkei*, thus some days (August 9, 1929) it was present in great numbers, several to a square foot of nest surface, running about over the surface of the mound, in the grass on the moist soil around the nest, and coming in and out of the gallery openings with the *ulkei* workers, especially the openings near the base of the dome of the nest. On this date it was also present in numbers within the nest itself, at the ground level and the intervening galleries to the most superficial ones. On other days (August 16, 1929) it was almost absent, several being taken from three nests. Again, the species would appear to frequent some nests rather than others in common with *Batrisodes* and other myrmecocoles. Thus one nest would yield a number of the carabids while adjacent nests would be almost devoid of myrmecocoles. I have found *incurva* to be the most abundant beetle myrmecocole of *ulkei* at Palos,

as well as at Palatine on August 6, the only trip made to the latter locality.

This carabid appears to occupy a most fortunate position in the *ulkei* community. It is practically unmolested by the worker ants at all times, as mentioned before the beetles running in and out of the galleries at will, undisturbed by the ants, and occasionally becoming motionless when an ant passes them. The carabids were killed on several occasions and placed on the surface of the mounds at Palos Park, and the worker ants did not molest the beetles very much more when dead than when alive. Thus, although the *ulkei* were bringing in all sorts of insects, dead or alive, for consumption, the dead *Tachyura* would often be passed by a worker, occasionally investigated, and rarely picked up. In the latter case, the worker would shortly drop the beetle and walk away. This was also observed in laboratory nests of *ulkei*.

On the other hand the larvae (Carabidae?) taken at Palos and at Palatine, when placed with *ulkei* workers, were pursued and one was devoured by the ants.

Observation of *Tachyura* shows that, although unmolested by the other members of the *ulkei* community so far observed, the carabids prey at will on anything they can devour. In this they resemble the behavior of the hyaena, only attacking when their prey is dead or sufficiently disabled to be harmless, as the following points will indicate.

In the first place, these carabids are essentially cannibalistic, and given a dead or disabled *incurva*, it is seized by others if they are within a sufficiently short distance to be stimulated by the food. Apparently the beetles must be within several milimeters before the presence of food stimulates them, and if the latter is removed a short distance away they have difficulty in again locating it. If one of the beetles finds the food it seizes it in its mandibles and quickly hides with the morsel where it can devour it unmolested. If two or more of the beetles find the food at the same time, or discover one feeding, they immediately attempt to take the morsel away, and tug and pull the food about until each obtains a portion, or one manages to run away with the whole, of their dead comrade. Such behavior is only shown in the presence of food apparently, as the

species can be kept in confined quarters in great numbers and the individuals will not fight or molest one another as long as they are in good condition.

If the food is too heavy to be taken away, the *incurva* feed on the prey *in situ*. Where possible pieces are pulled off and these are taken off and surreptitiously eaten, upon which the beetle returns again for another morsel. Thus it is a common sight to the experimenter to see six to ten *incurva* tugging and biting at such large prey as the larger Muscidae *(Lucilia, Calliphora)*, feeding on the fly, with the beetles distributed in a circle about the victim, each beetle with a certain section of the carcass. Under these conditions when a beetle leaves its place and attempts to dislodge a neighbor, the latter bites at the intruder and usually drives it away.

The *incurva* usually attack the mouth-parts of their prey first (Fig. 1) and these are sucked or licked for the moisture obtained. Before attacking such a fly, the beetle will often circle it several times, biting at the sclerites and wings in passing and then invariably settle on the moist mouth region or the membranous joints between segments of the legs and body sclertes. However, if a wound is first made in the fly, this is attacked as readily as the mouth-parts.

Even more readily is a dead or disabled worker of the host ant, *ulkei*, attacked. The behavior is essentially the same, the beetles showing a preference for the mouth parts glistening with regurgitated fluid. If the head of the ant is crushed a drop of fluid is forced on the mouth-parts and this is rapidly devoured by the beetles, often one on one of the ant's mandibles, and a second on the other side of the head, the two biting at each other when they are too close or driving away other beetles from this region. Occasionally the gaster of the ant is licked, possible for the oily secretion, and the antennae and leg joints, or wounds are attacked.

The queens of the guest ant, *Solenopsis molesta*, living with *Formica ulkei*, are attacked by the latter when possible (Park T. Loc. cit.) and *Tachyura* feeds on *molesta* also. Here the *molesta* queen is devoured in the same way

that the *ulkei* workers are, the mouth-parts being most stimulating to the beetles.

Finally, the mouth-parts of *ulkei* workers have been wiped as dry as possible and then covered with a drop of saturated sugar solution. The *incurva* sucked or licked the mouth-parts as dry as though the fluid had been regurgitated by the ant. To see whether or not the laboratory sugar solution would be eaten if given them as such, drops of the fluid were placed on bits of paper or wood, and the *incurva* fought and gathered about these drops until they had eaten all of it, as though the species were accustomed to such a diet in nature.

In addition to this varied diet of *incurva,* the species has also been seen to devour crushed larvae and pupae of the host ant, *Formica ulkei,* and the myrmecocolous staphylinid, *Atheta polita* as well as attack the larvae of the syrphid, *Microdon,* taken from the same host nest, when the latter's soft, ventral creeping surface was exposed.

From such observations one obtains a fragmentary picture of the place held by *Tachyura incurva* in the *ulkei* biocoenose, viz., that of a relatively unmolested species feeding upon the stores of food carried in by the *ulkei* workers, and attacking both the host ants, and the other co-inhabitants of the nest when these are dead or disabled. It is possible, although improbable, that the *incurva* may even creep up and steal some of the regurgitated fluid being given to a worker *ulkei* by another, as is the custom of certain synoeketes *(Atelura formicaria),* although its general habits tend to place the species in the role of scavenger. In return for this abundance of food and protection from the enemies of the carabidae (birds, toads, insectivorous mammals, and predaceous insects in general) which give the ulkei mounds a wide berth, the *incurva* perform the doubtful favor of aiding in removing nest refuse, a task which is ably performed by the ants themselves.

Response to Moisture

Other things being equal, the temperature of the *ulkei* mounds is more constant than that of the surrounding

environment (Holmquist, l. c.) and the galleries run to the superficial water table, and are consequently always moist, even in the hot, dry summer months. In such nests a temperature and a moisture gradient exists and either of these factors, or both, may have important effects upon the behavior of the inhabitants of the *ulkei* nest.

That moisture is important in the life of *testaceus* is shown by the following experiment:

Following the technique of Allee (1926), dry filter paper was cut to fit the bottom of petri dishes and in three such dishes two *testaceus* were placed. The beetles alternately walked, paused or ran about in their characteristic manner described later, for an hour and a half. During this time they were very active, crawling up the sides to the glass roof and then returning to the filter paper. At the end of this time a drop of water was placed on the filter paper at a definite point (A) on one side of each dish. In each dish the beetles located the moistened area within five minutes after its absorption. Once, having traveled through this wet area, they invariably paused, turned back, and after running back and forth in the moist area, each time halting at the periphery of the moistened spot, finally crouched in this spot and remained motionless, the head and antennae resting on the paper.

This motionless state was broken at intervals and the beetles ran about within the spot of moisture, apparently at random but trapped by their physiological requirements in a way suggestive of trapped *Paramecia* in acidulated water as described by Jennings.

As the area "A" became larger, and the surface more and more dry, the leptinids were correspondingly more and more restless, until, with the filter paper with a more or less uniform degree of moisture, the beetles had regained their normal activity and ran restlessly about.

This behavior was repeated at will in two of the three experimental petri dishes, with the same results. In the third the paper was allowed to dry over night by placing it on a table and covering it with the glass top, the glass bottom of the petri dish being removed. The next morning the leptinids were found dead, and strangely enough, in the

area "A", as if these unfortunates had run about until exhausted in the dry atmosphere, and had returned to die in the originally moistened area.

A fourth petri dish, with no filter paper over the bottom, was used as a partial control and the two leptinids therein were normally active throughout the experiment, hiding in the loose soil covering the bottom or walking over the glass sides of the dish. It is doubtful if the presence of the filter paper, rather than moisture, was the cause of the behavior of the experimental animals, especially since in these latter cases, the dry areas of the filter paper acted as a partial control as well as the dish with slightly moistened soil.

The above experiment was repeated with *testaceus* with the same results, and also with *Batrisodes*. In the case of the pselaphids, ten were placed in a petri dish, instead of two leptinids. Random walking about was observed for an hour, and then with the moistening of the filter paper at a definite point as before, the pselaphids soon found this area, and a few minutes later were motionless in the center, viz. the moist wet portion of the filter paper. The large number of the pselaphids made possible the use of larger groups in the experimental dishes, and the beetles were seen to aggregate in the center of the moist area. Usually this place aggregation was motionless, relatively, the beetles resting quietly on the paper, frequently with their legs and antennae touching each other. Such an aggregation reminds one of the bunching of land isopods under similar conditions (Allee, 1926, 1927), and may be partially explained as a contact aggregation in which the limited moistened area and subsequent crowding formed the aggregation. On the other hand, the pselaphids, *Batrisodes globosus* and *denticollis,* may very well exhibit a normal tendency to collect in pockets or portions of galleries of their host's mound. In either case, a relative amount of moisture may be cited as an important stimulus.

As in *testaceus,* the pselaphids, when left over night on the drying filter paper, were found dead the following morning, loosely bunched on the center of the previously moistened section.

Batrisodes were used in a variant of the above experiment. The aggregation was allowed to form on the moistened part, and then additional water was added until this area was saturated. Under these conditions, the beetles became restless, and the aggregation rapidly broke up, indicating that too much moisture is as stimulating as not enough. This last response has been found for similarly induced gatherings of land isopods (Allee, 1926).

Such gatherings upon moistened areas of filter paper, when induced, are not necessarily motionless. At intervals one or more of the aggregants will rise and wander about, to return usually to the crowded section. Even when the group is quiet, individuals frequently tap the paper or one another with their legs or antennae.

Response to Light

Petri dishes with a diameter of 14.5 centimeters and a depth of 3.5 centimeters were so covered with light-tight paper that one half of the dish would be in shadow when placed under a 40 Watt Mazda lamp giving approximately 120 foot-candles at 35 centimeters, (measured with a Macbeth illuminometer). The experiments were run at night to avoid light from any other source, and were conducted for six trials of a minute each, with a dark interval of half a minute between trials. The animals were given a one minute adjustment period prior to the first trial of each experiment, as the species used had a tendency to run rapidly about the dish at first. The experiments were short also, to obviate the rise in temperature as much as possible, the latter being fairly constant, running from 28.5 to 30.5° C. for one experiment. The glass top of the petri dish, one half of which was light-tight, was rotated 180° between successive trials to vary the portion of the dish shaded.

Under these conditions, the following results may be mentioned:

1. The carnivorus *Tachyura incurva*, in common with many of the related carabids, was photo-negative under the experiments as described. This may very well indicate a nocturnal active phase, the species being taken through-

out the Chicago area from April to October on the forest floor under leaves, and under bark of logs by day. It is evident, then, that a photo-negative, predaceous carabid should be at home in the dark, moist galleries of *ulkei*.

The degree of positive or negative response to light was calculated in percentage of time the animal spent in the illuminated or darkened portion of the petri dish. Under these conditions, *incurva* was consistently 85 to 90% photo-negative.

2. The pselaphids, *Batrisodes*, were less strongly photo-negative averaging 60% of the time in the darkened area.

3. The blind *Leptinus testaceus* was completely indifferent to the light used, walking about the periphery of the petri dish in a steady movement, half of the time in the shadow, and half of the time in the light, which is in accord with its morphological make-up.

It is clear that light does not play the prominent role that moisture does in these last two species of myrmecocoles.

Activity

The carabid, *Tachyura incurva*, the pselaphids, *Batrisodes globosus* and *denticollis*, and the leptinid, *Leptinus testaceus*, are as distinct in their locomotion and general activity as they are in morphological habitus. The pselaphids have a rather slow, regular walk, their legs moving in a stiff clock-like precision reminiscent of many Histeridae and the parnoid families, Dryopidae and Elmidae. They are essentially awkward, readily become upset and right themselves with the greatest difficulty.

On the other hand, *Tachyura* is much more active, and rights itself more easily. *Leptinus testaceus*, in consequence of its great width in proportion to its depth of body, loses its balance only rarely and then rights itself with ease. Being so flat it may creep into narrow crevices between particles of soil and hide, as was frequently observed, the general body plan reminding one of the flattened Cucujidae, Nitidulidae, the histerids *Hololepta* and *Platysoma*, the flat bark bugs, Aradidae, the exotic forms, as the carabid,

Mormolyce, and others which live normally beneath bark. The movement of *testaceus* is peculiar. The individuals observed are given to frequent, short pauses in their running, and exhibited an unusually quick change of pace and direction. In consequence of this behavior, their normal gait is a darting movement.

The speed of these three species, and of the host, *Formica ulkei,* may be mentioned as interesting. Individuals were

Fig. 1. *Tachyura incurva* (Say) feeding on the host ant, *Formica ulkei* Emery. Photographed from life by Carl Welty.

placed on a wide expanse of concrete floor, their path traced in with chalk and the distance covered in a unit of time taken with a stop watch.

Workers of *Formica ulkei,* and the predator, *Tachyura incurva* are both relatively rapid travelers, moving, when stimulated, between 150 and 200 centimeters per minute. *Ulkei* workers, however, do not hold this speed for repeated trials.

Batrisodes is slower, moving between 65 and 80 centimeters a minute on the average, and *Leptinus testaceus* was found to be the slowest species examined, averaging 30 to 50 centimeters a minute. Usually *testaceus* is more rapid in its running than the pselaphids, attaining a much higher speed than the average cited, but its frequent pauses bring down the average time. When *testaceus* is unduly stimulated, instead of running rapidly away as do the *ulkei* workers and *Tachyura,* it tends to letisimulate. Thus in one series of trials it averaged five periods of death-feigning per minute and covered on the average only 4.2 centimeters. Such behavior, in addition to its hiding proclivity, would indicate that it met danger first by rapid darting, and then finally seeking safety in immobility, with the head and prothorax deflected and the antennae and legs more or less protected by the shield like margins of the body. At least the death feint, so-called, is pronounced in the species when induced by contact stimuli, and the resulting quiet state may be a reflex response. Whether such a condition would prevent its being attacked is problematical.

As would be expected, individual beetles showed individuality in their rate of locomotion, some being consistently faster than others, and one *testaceus* was far more prone to letisimulate than any of the others used.

Similarly, there was a gradual loss of activity in the laboratory animals, their rate of locomotion being much higher when brought in from the nests than several days later.

Despite such complicating factors entering into the question of activity, the species used showed a differential speed of running, and this fact may be significant. Thus these observations make it probable, and indeed rather obvious, that the predative inhabitants (synecthrans, Wheeler, (1926), by the very conditions of their existence, should be more active, and move faster than the less persecuted synoeketes and symphiles, and the latter slower than the synoeketes. Exceptions of course are to be expected.

SUMMARY

In this paper the term "myrmecocoles" is suggested to cover the organisms found in the nests of ants, irrespective of degree of association with the host ant, viz. accidental occurrence to the symphiles and parasites, and a supplementary list of the myrmecocoles of *Formica ulkei* is given.

Certain ecological interrelationships have been observed among the beetles inhabiting the nests of the mound-building ant, *Formica ulkei* Emery and experiments have been made to determine their general behavior with respect to the biotic factors of enemies and food and the physical factors of light and moisture as well as the differential activity of these species under laboratory conditions. It is suggested that the rate and character of locomotion of certain myrmecocoles may be a partial criterion in determining the degree of association between the species and its host ant.

Especial reference is made to the blind *Leptinus testaceus* Müll. and its behavior as possibly throwing some light upon its ecological status, as well as the carabid, *Tachyura incurva* (Say), and the pselaphids, *Batrisodes globosus* (Lec.) and *B. denticollis* Casey.

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LEMA PALUSTRIS BLATCHLEY. A nice series of this rather uncommon beetle was taken in Framingham on June 16, 1929, by sweeping the budding plants of the Canada thistle; a week later they had disappeared entirely. Previous to 1913 this species was considered to be *brunnicollis Lac.* which is a more southern species.

C. A. Frost, Framingham, Mass.

NOTES ON THE STRUCTURE AND SIGNIFICANCE OF PALAEOGYRINUS[1]

By P. J. Darlington Jr.

The beetle family Palaeogyrinidæ was erected by D. H. R. von Schlechtendal in 1894 to contain the single genus Palæogyrinus, described from the obverse and reverse of a single fossil specimen from the Upper Oligocene deposites of Rott in Siebengebirge, Prussia. Concerning the later vicissitudes of the genus it should be sufficient to say that Handlirsch, in "*Die Fossilen Insekten*," placed it directly in the Gyrinidae, leaving it there, without a query, in Schroder's "*Handbuch*" and that Hatch[2] has recently removed it and placed it as a separate subfamily of the Dytiscidae.

The characters given for the genus by von Schlechtendal were simple and striking. The most important was the compression of the tarsi of the *middle* legs for swimming, and, if the figure which accompanies the original description is accurate, the tarsi were very highly specialized indeed. The undivided eyes and the presence of a mesosternum larger than that of the Dytiscidae were considered of secondary importance. Von Schlechtendal's figure, which is repeated by Hatch, shows the external structure of the beetle in some detail, but, when considered in conjunction with the text, is obviously in part a reconstruction. Except for the tarsi, the insect is almost wholly dytiscoid.

Much might be written of Palæogyrinus as originally described, indeed remarks on its significance as a link between the Dytiscidae and the Gyrinidae have already been

[1]Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 320.

[2] Bulletin Brooklyn Entomological Society, 1927, Vol. 22, No. 2, p. 89: On page 94 will be found a bibliography of reference to *Palaeogyrinus* which need not be repeated here.

published, but under the circumstances I shall refrain from a discussion and shall be content with pointing out certain facts which seem thus far to have escaped notice, and which at once reduce the matter to its simplest elements.

To return to the most important character, the structure of the middle legs, a glance at von Schlechtendal's figure will show that, in spite of the huge tarsi, comparable in their development with the swimming feet of such powerful divers as Laccophilus and Cybister, the femora are slender, and the coxae drawn so small that the whole leg is grotesquely disproportioned. Furthermore, the posterior legs have powerful femora hinged to broad coxal plates, but have no recognizable tarsi, though we should expect to find heavy ones attached to such bases. Now if tibiae should be drawn between the hind femora and the so-called middle tarsi, a pair of well-proportioned swimming legs would be formed in a position in which they are found in a good percentage of recently killed dytiscids today, and we should have to assume the loss of the imprints of only the typically slender mesotarsi, which might actually be covered by those of the heavy hind legs. Thus by a small change, and reference to the original figure will show how slight it would need to be, we should replace an anomalous and unconvincing insect by a nearly typical dytiscid, such as might well have occurred in the geological period in question. Any doubt that this suggested reconstruction is the correct one in spite of the original figure is, I think, removed by von Schlechtendal's own statement that the different parts of the posterior legs cannot be surely recognized, since they have left only slight impressions.

Among the characters of secondary importance, the entire eyes indicate at once the dytiscid affinities of the insect, as do the rest of the discernible structures except, perhaps, the mesosternum. As the latter is figured it is larger than in the Dytiscidae, but if, as we may suspect, the suture between it and the metasternum is imagined or due to a crack in the rock, we should avoid even this difficulty, for an anterior projection of the metasternum would meet the intercoxal process of the prosternum, the typical

dytiscid condition. The so-called mesosternum should certainly be re-examined with this possibility in view.

To restate the case, Palaeogyrinus is a fossil which looks like a dytiscid, with a coxal structure demanding that the posterior and no other legs be highly developed, and which is said in the original text to be poorly preserved in the very place where the reconstruction is most remarkable. The conclusion must be that the insect was a dytiscid, but that it may have had an unusually large mesosternum. It is rather surprising that these facts have not been brought out before.

I do not believe it is possible to place Palæogyrinus accurately with relation to living genera, and see no reason to attempt it, since the placing would be a matter of guess work and might lead to confusion. The genus is interesting, therefore, chiefly because it is an example of a more or less typical dytiscid from the Upper Oligocene. It has also a temporary interest in that it provides an excuse for a few remarks on the place of fossils in the study of Coleoptera.

Among orders where there are good characters in the wing venation fossils are often reliable, as they are in other groups when good series of good specimens are available, as, for instance, in the case of the Florissant ants which have recently been studied by my friend Dr. F. M. Carpenter. Unfortunately, however, the parts of beetles which are usually preserved have few diagnostic characters, nor are good series of fossil specimens usually obtained. The placing of a species by examination of a single elytron from any but the most recent deposites must depend upon the unwarranted assumption that the beetle fauna of a given period was practically the same as that now existing. It is difficult to see the value of generic and specific descriptions of such nearly unidentifiable remains, when the greatest care and some faith are required to classify even a fairly complete specimen. This does not mean that fossil beetles have no value, but rather that their value is limited, the limit depending in each case on the number of characters actually observable in the fossil itself. There is a good deal of random guessing and specious reasoning to be

eliminated before "Palaeocoleopterology" can be taken without a grain of salt.

I am not a palaeontologist until forced by circumstances and can make no general statement on my own responsibility, but I have discussed the matter with experienced friends who agree that, although a fossil insect may be rather loosely said to be in two dimensions, it can rarely be "adequately recorded in the form of figures" as stated by Mr. Hatch, and most emphatically should not be studied in that form alone. Indeed, the history of Palæogyrinus suggests that it may be more important to see the type of a fossil than of a living species.

European Coleoptera at Providence, R. I., in 1928.

Several specimens of A*grilus coeruleus Rossi* were taken on June 16, 1926; they were determined by Mr. C. A. Frost of Framingham, Mass.

On October 12, 1919, a fine specimen of *Geotrupes* was taken and not being like any of the described North American species it was submitted to Mr. H. C. Fall of Tyngsboro, Mass., who stated that it resembled the European *G. sylvaticus* Panz. in his collection. I find that the specimen answers very well to the description of this species in Thompson's Scandinavian Insects.

J. V. Nylen, Providence, R. I.

A PRELIMINARY STUDY OF THE TRACHEAL SYSTEM OF THE MATURE LARVA OF *BLEPHARIPA SCUTELLATA* R-DESVOIDY.[1]

By Milton F. Crowell.

Blepharipa scutellata R-Desvoidy is one of the imported parasites of the gypsy moth, *Porthetria dispar* (L). The individuals studied emerged from pupae of the moth collected in July 1929, in southern New Hampshire. I had but four larvae and one puparium to examine, hence the study of this insect is by no means complete, and note can be made of only the more obvious features.

The larva of this insect has the amphipneustic type of respiratory system (Palmen 1877, DeGuyse 1926) characterized by one pair of functional spiracles on the prothorax and from one to three pairs of functional spiracles at the end of the body. This is considered to be a secondary, physiological type, (DeGuyse 1926), but the larvæ of muscoid flies possess a higher type in a rudimentary, or nascent state.

The Spiracles.

The anterior pair of spiracles was not observed in detail. Their general position was noted in a study made of the tracheae visible through the integument at the cephalic end of the body. The main tracheal trunk appeared to bend upward and join the body wall near the posterior margin of the prothorax. Since Snodgrass (1924) found the prothoracic larval spiracles of *Rhagoletis pomonella* Walsh (the apple maggot) to be located in a position similar to these

[1]Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 321.

observed tracheal endings, the conclusion that these endings indicate the position of the spiracles seems warranted. (Fig. 1).

At the posterior end of the body are two fairly heavy chitinous rings marking the edges of the spiracles. In each of these, covering the spiracle openings, are chitinous plates which vary in their thickness. I was unable to see any openings through these plates. Greene, describing puparia of muscoid flies, (1921), states that "each plate has two or more openings for respiration, and these openings are called *"slits;"* Snodgrass (1924) describes the openings in the stigmatic plates of *Rhagoletis.*

Just beneath the stigmatic plate is the stigmatic chamber. The walls of this chamber are slightly thicker than the tracheal walls to which they are joined, and they are somewhat pigmented. Upon drying a reddish, rusty-looking deposit appeared on the walls and upon the interior surface of the stigmatic plate.

No lateral spiracles are observable on the larva.

Parkard (1874) in a short table of spiracular positions says that the larvae of Cecidomyiidae have nine pairs; one prothoracic, and eight abdominal, and that Muscidae have two pairs, one prothoracic, and one on the ninth abdominal segment. Further (1898), he says that the number of pairs varies in larval Diptera in adaptation to their varied modes of life.

Pratt (1897) figures an embryo of *Melophagus ovinus* (Linn) with a row of ten small circles inside of each of which is a smaller circle, which he designates as "Tracheal invaginations." Williams (1910) states that the larva of *Cecidomyia resinicoloides* Williams (Cecidomyiidae) has nine pairs of spiracles, "one on the first thoracic segment and one each on segments 4-11."

Snodgrass (1924) says that eight pairs of spiracles appear on the puparium of *Rhagoletis,* and he cites various authors to the effect that the lateral spiracles in larvae of the higher Diptera are present as imaginal discs.

It would appear, therefore, that in the higher Diptera the lateral spiracles are not absent, but remain in an undeveloped state until they take part in the formation of the

peripneustic system of the adult. Palmen (1877) describes the removal of the larval tracheal lining through the rudimentary spiracles of Ephemerida and Trichoptera. The rudimentary second thoracic spiracle of *Pyrausta nubilalis* Hubn. (European corn borer: Lepidoptera) functions in the removal of the tracheal linings from the body at pupation. Snodgrass (1924) says that the lateral spiracles of the puparium of *Rhagoletis* are opened in the pupal stage by the shedding of the tracheal linings.

The Longitudinal Trunks.

On each side of the body is a large tracheal trunk. These are very large at their attachment to the walls of the stigmal chambers, and they taper to the anterior end of the body, where they divide into several smaller branches. Besides a gradual taper, these trunks taper abruptly at several places, and have somewhat the aspect of a telescope.

These trunks represent the dorsal longitudinal trunks (Dt fig. 2.), which, in the Trichoptera larvae are very much smaller than the ventral trunks, and which are apparently present only in the thorax of larval Lepidoptera.

The ventral longitudinal trunks (Vt fig. 2) which, according to Snodgrass (1924), send branches to the rudimentary spirales in *Rhagoletis,* and which are connected with the open spiracles in *Cecidomyia* (Williams 1910), appear in *Blepharipa* as anastomosing branches from the large dorsal trunks.

The dorsal trunks lie within the body cavity and are not crossed by muscles, as are the longitudinal trunks of the lepidopterous larvae. The ventral trunk is crossed by a muscle in the first abdominal segment (m1 fig. 2.), and further investigation may show this condition present in the other body segments.

Transverse Tracheæ.

Snodgrass (1924) states that in *Rhagoletis* the dorsal trunks are connected by a dorsal commissure in all segments

but the first; the first and the last being larger than the others, and going straight across. Williams (1910) figures and describes dorsal transverse tracheae in segments four to nine in *Cecidomyia.*

In *Blepharipa* I found, in the anterior part of the body, three transverse tracheae. The first springs from a branch of the dorsal trunk near the point of its division into several branches mentioned above. The origin of this branch lies beneath the protractor muscles of the pharynx, and the trachea bends around these muscles and crosses them, and the posterior part of the pharynx. No branches arise from it.

Rising from the opposite side of the dorsal trunk, apparantly at about the same place as the branch from which the transverse branch described above arises, is a branch which divides into three parts. The termination of the anterior branch I do not know. The middle branch runs diagonally backward above the duct of the salivary gland (sg fig. 2) and above the ganglia and meets a branch from the opposite side arising from a similar position, and having a similar path. This transverse commissure may send two branches backward to the ganglia. In one specimen examined it apparently did so, and in another it apparently did not. The third branch also runs diagonally backward, and apparantly supplies the ganglia (br fig. 2).

Arising from a point slightly behind one opposite the middle of the ganglia is another trachea which meets a corresponding branch from the opposite side, making the third of the transverse tracheae mentioned above. This seems a short branch forward from its junction point.

Other transverse tracheae are probably present.

Tracheæ to the Nervous System.

At about the line between the third thoracic and first abdominal segments, probably lying in the metathorax, a branch springs from the dorsal trunk and runs forward (1 fig. 2). Just anterior to its junction with the dorsal trunk a branch springs from it and runs beneath it toward the middle of the body. This branch shortly divides into six

branches. The anterior one goes to the salivary gland. The next three run to the ganglia, and the posterior two supply fat bodies (fb fig. 2). The three tracheal branches here mentioned, together with the branches described in the former section on transverse tracheae, appear to be all of the branches to the "brain."

The ventral ganglionic mass (g figs. 2, 3), a large appendage of the brain lying ventral to the alimentary tract, receives its tracheae from branches from the ventral tracheal trunks (Vt fig. 3).

As far as I can determine from my notes the first ventral trachea to the abdominal central nervous system arises in

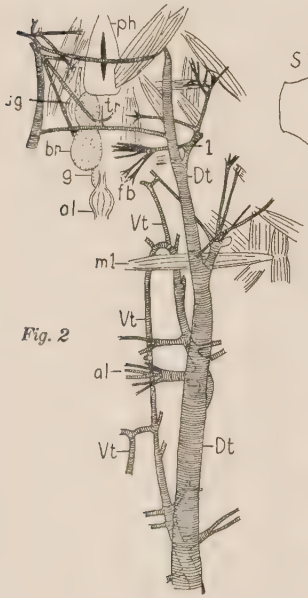

Fig. 2

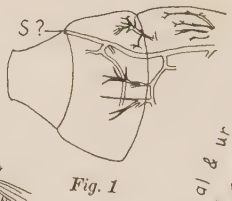

Fig. 1

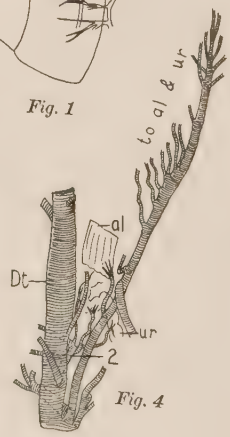

Fig. 4

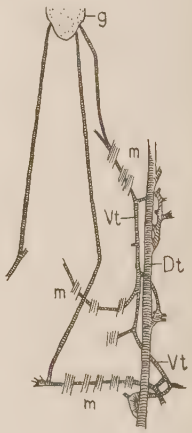

Fig. 3

Fig. 1. Sketch of tracheæ as seen through the body wall in the anterior end of a larva. Fig. 2. Tracheæ and organs in anterior part of body. Fig. 3. Tracheae to the ventral ganglionic mass. Fig. 4. Study of tracheæ in posterior end of body. al, alimentary tract, and tracheæ to alimentary tract; br, "brain"; Dt, dorsal tracheal trunk; fb, tracheæ to fat bodies; g, ventral ganglionic mass; m, muscle layer; ml, muscle crossing ventral tracheal tract; ph, pharynx; S?, position of anterior spiracle?; sg, salivary gland; tr, transverse trachea; ur, urinary tubule; Vt, ventral longitudinal trunk; 1, trachea branching to gland, ganglia and fat bodies; 2, trachea sending branches to urinary tubules.

the third abdominal segment. It runs diagonally forward and inward, crossing the second abdominal segment on the outside of the muscle layer (m,m,m, fig. 3) and sends a branch toward the middle of the body at about the middle of this segment; then it continues across the first abdominal segment, in the body cavity, no longer attached to the body by muscles, and joins the side of the ganglionic mass.

In the specimen examined, the fourth abdominal segment contained on the right side the trachea running outside of the muscle layer, but none that ran forward to the ganglia. However, the corresponding trachea on the left side sent a long branch forward across the third, second and first abdominal segments, to the ganglia.

In the fifth segment a branch from the right ventral longitudinal trunk ran almost directly inward between the muscles and the body wall to nearly the mid ventral line of the body, where a long branch arose running forward, crossing the fourth, third, second and first abdominal segments, in the body cavity, to the ganglion. None was present on the left side. This alternating right and left supply of tracheae to the central nervous system merits further investigation.

The tracheae, which ran between the muscles and the body wall apparently are homologous with the ventral transverse branches found in the lepidopterous and trichopterous larvae. In the larva of *Pyrausta nubilalis* Hubn. these tracheae form a transverse connection between the spiracles, except in the first abdominal segment. In the larvae of the Hydropsychidae studied by me these tracheae form transverse connections in the thorax but not in the abdomen, and in *Blepharipa*, they apparently do not form transverse connections. Snodgrass (1924) does not mention ventral commissures in *Rhagoletis;* and Williams (1910) does not mention them in *Cecidomyia,* but his figure (5 Pl. 6) apparently shows one in the metathorax.

Tracheæ to the Alimentary Tract and Urinary Tubules.

The alimentary tract (al figs. 2, 4) is supplied, in the anterior part of the body by branches springing from the

commissures between the dorsal and ventral longitudinal trunks near to the dorsal trunks (al fig. 2); the urinary tubules (ur fig. 4) are supplied in the same manner.

Arising from the stigmatic chamber, beside of the large dorsal trunk are several other tracheae. One of these runs forward and breaks up into many smaller branches which supply the alimentary tract and urinary vessels (to al and ur fig. 4). A branch arising from the dorsal trunk near to its junction with the stigmatic chamber also sends three good sized branches to the urinary tubules (2 fig. 4).

The Salivary Glands.

The salivary glands (sg fig. 2) are supplied with tracheae arising in a manner similar to those going to the alimentary tract.

The Muscles.

A study of figure 2 will make clear the supply of tracheae to the muscles much better than would a worded description.

Discussion

The present study is necessarily incomplete, because of lack of material, and too superficial to allow of any but the most general conclusions to be drawn.

It does seem safe, however, to say that apparently the trichopterous, lepidopterous, and dipterous tracheal systems are variations of the same general scheme. This statement could not be made, however, were it not for the excellent works freely cited in the text.

The Trichoptera, as shown by Palmen (1877), possess rudimentary spiracles from which are developed the spiracles of the imago. In a study which I have made, but which has not been prepared for publication, I found that other than lacking functional spiracles, and possessing tracheal gills, the trichopterous larval tracheal system is very similar to that of the lepidopterous larva. The dipterous larval tracheal systems vary, as noted by Packard (1898), but here we have, in the Cecidomyiidae (Williams, 1910) open spiracles with a small ventral system, corresponding to the main longitudinal tracheae of the

Lepidoptera and Trichoptera, with a large dorsal system corresponding to the small dorsal system of the Trichoptera. Should a study of the tracheal systems of the more generalized Diptera show them to possess a system yet more similar to that found in the Trichoptera, it might be possible to make a real homology of the various tracheal branches in the three orders. *Blepharipa,* and other muscoids, apparently have but carried the specialization shown in *Cecidomyia* a few steps farther, and not really departed from the general type.

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DOWN WITH THE TYPE-CULT.

By Professor Embrik Strand

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F.E.S., F.Z.S., F.L.S.

The "Type", *i. e.*, the object on which the definition or description of a zoological novity is founded, is an idea that did not become of great importance in zoology until modern times. Among the earlier workers on systematics "types" practically did not exist. Later on we find in the literature the designation "type" here and there, but still no one thought of determining the priority of species on the "types". To-day we are so "advanced" that numerous authors, especially those who choose to call themselves "specialists", found their species almost exclusively on the "types", while the description and eventually the figure are considered as a matter of quite secondary importance, or as merely a matter of form, in spite of the fact that the modern rules of nomenclature, as well as those which Linné, Fabricius, etc. used *exclusively* acknowledge a definition or a description as the basis which alone can be the foundation of priority. Thence it follows, that the establishment of species on the basis of "types" is opposed to the rules of nomenclature, and even if one asserts that the types have been used only in order to verify and better the descriptions, that is likewise an abuse, if it leads to conclusions that are quite contradictory to the description. In using "types" there are so many particulars which may turn out to be quite misleading or may lead one astray and give rise to *abuse*, that it is difficult to understand why people, who are not wholly lacking in a knowledge of men and matters, do

not discover and notice such particulars themselves. A partial explanation may lie in the fact that the type-cult, as a matter of *fashion,* is not readily eliminated. A fashion may be quite ridiculous, nevertheless the masses adore it. The most reasonable explanation may be, however, that the "specialists", who are to-day dominating systematic natural history can most easily maintain their hegemony through the type-cult and thus are personally interested in it. Now and then, however, voices are heard which protest against the worst sides of the type-cult. We find *e. g.,* in the Stettiner Entomologische Zeitung, 1928, p. 63, seq., a paper by R. Kleine on the types of the Brenthidae, in which he points out in his introduction that the description is and has to be a primary and the type a secondary consideration. The types in most cases are not accessible to the worker, and shortly it will be quite impossible to write a monograph if an examination of the types is to be considered a necessary prerequisite for such work. Only he who is in favor with the keeper of the types can get access to them; moreover, Kleine asks: "who guarantees that the animal designated as 'type' really is the type?", for he adds: "the strangest things have at times taken place" (he is doubtless quite right). He also asks how the types in many cases are preserved, further where are they preserved, and finally he concludes, that the description represents everything and that we must proceed so far as to release monographers from the necessity of examining the types. What Kleine thus emphasizes so far is quite right; however, as we shall see it represents only half the truth and when he (*l. c.* p. 63) quotes the assertion of an American entomologist that hardly one-quarter of the 20,000 American insects which have so far been described can be determined from the description alone, I am astonished that he is so credulous.

More extensively and more clearly, but not sharply enough, Edmund Reitter expresses his opinion on the same topic in the Wiener Entomologische Zeitung, vol. 31, p. 21-26 (1912). He emphasizes how unjust and absurb it is to declare species null and void, when so called "types" are not in accordance with the description. Types may be easily misleading as a result of misplaced labels, damage,

etc., and to this is to be added that such misplacements can be made *intentionally* and that in the case of a printed description this is quite out of the question. Here we must do what Reitter did not do, expressly emphasize that the description is quite an absolutely constant, invariable thing which is accessible to the whole world. Accordingly, misapprehensions may at any time be corrected by anyone and from different viewpoints while the examiner of "types" is often in the position so he can decree his "discoveries" to the credulous entomological public without any disputation from others. Another point which Reitter does not mention but which in my opinion is of *very great importance*, is the following: the entomological public is obviously always apt to place more confidence in the new "examiner" of the "type" than in the original describer. That is quite wrong for logical as well as for psychological reasons; the reverse is right. It is most certainly the author of the species who has every reason, including his personal interest, to examine the "types" precisely and conscientiously. The new "examiner", however, is liable to present himself, either unconsciously or not, to the public as a discoverer, wiser person, and improver, and this liability can easily cause him to "discover" differences in the "type" which in reality exist only in his own imagination. If the eye of the "reviser" has been influenced by *personal animosity*, envy or hatred, then it is no wonder that the results of the "examination" are often peculiar. Moreover, we should bear in mind that what is to be seen on an entomological type, depends greatly upon the examiner himself; one may see distinct differences which another who has the best intentions and makes the greatest efforts does not see. Who guarantees that the new examiner of the type is abler than the original describer in this respect? I think that it has often happened that the "reviser" has degraded a number of species into synonyms because he did not see the distinctive marks which the original describer stated, and which in reality are present. Reitter speaks *(l. c.)* of the pronounced endeavor of many authors to change the usual synonymy on account of more or less problematic "types" and to degrade the species of other authors into synonyms and he asks what the end will

be when the "type-madness" proceeds so far as to consider the type as all and the description as a mere matter of form. Another point in the "examinations" of "types" which likewise has not been taken into consideration by Reitter and which is often of decisive importance, is the fact that if a "specialist" personally cannot have some "types" for the sake of examination, he writes some correspondent, who lives in the town where the types are preserved and asks him to examine the types. In order to show his superiority in this domain the specialist does not forget in the same letter to suggest that type A may be cospecific to species X and type B to species Y etc., and then asks the correspondent to settle this question. The correspondent compares type A with species X but has no specific knowledge of the group in question and consequently he does not know which items in this question are of most importance and he is not trained to find the distinctive marks which will decide the matter. Under these circumstances it is no wonder that he is not willing to spend much time in order to study the matter. For logical and psychological reasons one can be sure that the answer of the correspondent at all events will be affirmative in such cases, for he will not be able to voice a final opinion contrary to the opinion which "Mr. Specialist" had already expressed or at least indicated. Consequently the correspondent finishes the matter with "it may be so" and the specialist proclaims triumphantly that comparison of types has proved that his supposition was quite right. I could mention concrete examples of such *swindles*. The whole "comparison of types" proves in such cases to be a comedy which the "specialist" utilizes in order to make the entomological public believe that which is agreeable to the "specialist".

For this reason I have always considerer types as of no great importance and the descriptions have always been the main point to me, and for this point of view I now stand more than ever. Consequently: Down With the Type-Cult!

NOTES ON REPRODUCTION IN *ASPIDIOTUS HEDERÆ* (COCCIDÆ).

By Franz Schrader

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Our present knowledge of the reproductive processes in the Diaspinæ is a very limited one. The following observations represent a rather cursory attack on this aspect of the biology of the oleander scale *(Aspidiotus hederæ)* and in view of the lack of similar studies on this group of Coccidæ no attempt is made to arrive at any final and concluding generalizations.

The study had its inception in the very interesting paper of E. Gabritschevsky ('25) and so far as its more particular purpose is concerned, hinges especially on Gabritschevsky's statement regarding *Aspidiotus hederæ* that "bisexual cultures live on the plant *Aucuba japonica;* parthenogenetic or unisexually-female cultures grow best on a variety of palms." It will be seen that Gabritschevsky does not commit himself on a possible relationship between host plant and mode of reproduction and it is only fair to state that he was not primarily concerned with that aspect. Nevertheless, the possibility that there might be some correlation between the type of host plant and the presence or absence of males induced me to investigate the species with this point in view.

Parthenogenesis has been reported for various Diaspinæ on several occasions. However so far as I know, no controlled experiments have been made to sustain these contentions and certainly the observed scarcity or absence of males in several instances is insufficient to establish the point.

In the present case, the work took the following form: The stock cultures were derived from oleander plants. Larvae that had just escaped from the egg were isolated on plants which had been cleaned with great care, and the plants were then covered with lamp chimneys whose tops were covered with fine meshed gauze.

Many of the insects were injured in the transfer and died within a short time. Some others apparently attached themselves successfully but died during more or less advanced instars. Out of 34 larvae that attached themselves after isolation only 9 reached the reproductive stage, the deaths being distributed approximately evenly over the various instars. The host plants used were *Aucuba japonica, Hedera helix,* and an unidentified palm. The offspring of the isolated insects were not counted until they themselves had reached the adult stage. This was done because of the great difficulty of counting the migrating larvae that have just hatched and means of course that the number of individuals in each brood as here given is not as great as the number of eggs or first instars produced by each isolated insect.

	Date of Isolation	Host	Young first appeared	Number reaching adult stage.	Sex
1.	Oct. 7	Hedera	Feb. 1	12	Female
2.	Oct. 7	Hedera	Feb. 3	28	Female
3.	Oct. 22	Hedera	Feb. 10	10	Female
4.	Oct. 7	Aucuba	Jan. 2	50	Female
5.	Oct. 7	Aucuba	Jan. 4	10	Female
6.	Oct. 7	Aucuba	Jan. 8	24	Female
7.	Oct. 22	Aucuba	Jan. 28	45	Female
8.[1]	Jan. 10	Aucuba	April 1	52	Female
9.	Oct.	Palm	Jan. 15	9	Female

The breeding experiments demonstrate the following points: *a.* The nine isolated individuals as well as all of their offspring were females. No males arose on either palm or Hedera plants. *b.* Reproduction occurs without mating, regardless of the type of host plant. *c.* The life cycle is com-

[1]This individual was obtained from Experiment No. 4 and thus represents a second generation raised under control.

The temperature of the greenhouse used was very variable, ranging from 55° to 90° F.

pleted more quickly on Aucuba than on Hedera and palm.

In any other group of insects, this evidence might be deemed sufficient to demonstrate that parthenogenesis occurs in the species. But it must not be forgotten that it is in the Coccidae that a case of functional hermaphroditism is encountered *(Icerya purchasi,* one of the Monophlebinæ as reported by Hughes-Schrader, '25).

In such an instance no breeding experiments of the type I have described will in themselves settle the question. Only a cytological examination would finally decide the point and such an examination was made in Aspidiotus. This shows that not only is there no internal evidence of the presence of any male tissue in the females, but also that the maturation and development of the eggs follow a series of steps which is typical of so-called diploid parthenogenesis.

The somatic cells of immature as well as mature females carry 8 chromosomes. In the course of maturation of the egg, 8 chromosome threads are formed and these show no trace of bivalence or tetrad structure (Fig. 1.). 8 chromosomes also appear in the stages of final condensation (Fig. 2.) so that evidently there is no pairing of the chromosomes. Only a single meiotic division takes place and this is equational in nature, 8 chromosomes going to each pole. Apparently the polar body is not actually extruded but remains at the periphery while the egg nucleus migrates toward the center of the egg (Fig. 3.). Further divisions of this egg nucleus occur in a quite normal manner and the cleavage nuclei all carry 8 chromosomes. (Fig. 4.).

It is plain that taken together, the experimental and cytological evidence demonstrate that in this particular stock of *Aspidiotus hederæ* reproduction is parthenogenetic and normally results in nothing but females. But it would be rash to generalize on this basis. Males have certainly been described for the species and as mentioned above Gabritschevsky reports that males were produced on some of the plants under his observation. Indeed it may well be that some stocks of the species are more susceptible to environmental influence than others and that in such cases the host plant may drastically affect the process of re-

Fig. 1. Prophase stage showing 8 chromosome threads.

Fig. 2. Metaphase of maturation division.

Fig. 3. Telophase of maturation division, with polar body near periphery of the egg.

Fig. 4. Cleavage nucleus showing 8 chromosomes.

Drawn with 15X ocular and 2mm. oil immersion, using camera lucida.

production. Gabritschevsky's observations were made in Russia so that geographically at least the two stocks of insects used are widely separated. However for the present, I am inclined to adopt the explanation that is presented in the investigations of Thomsen ('27) on *Lecanium hemisphæricum* and *Lecanium hesperidum*. In both of these species there are two distinct races. In one race reproduction is always parthenogenetic and no males are found. The other race however is facultatively parthenogenetic and its eggs are capable of fertilization or, lacking that, of parthenogenetic development. The cytology of the two races is radically different. I suggest that in *Aspidiotus hederæ* also, there may be two races of this kind. The race that I have worked on reproduces solely through parthenogenesis and indeed, its cytology is in principle identical with the corresponding race of Lecanium. That the other race exists also is supported by the recorded occurrence of males as well as by Gabritschevsky's findings, who may well have had a mixed population composed of both the races in question.

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A NOTE ON *CHILOSIA HIAWATHA* SHANNON

By Charles W. Johnson

Boston Society of Natural History.

This species was described in 1922[1] from a single male collected by Dr. Jos. Bequaert at Forest Hills, Mass. On June 4, 1922, Mr. W. S. Brooks took a female at Topsfield, Mass., that I though might be *Chilosia haiwatha,* but the bare eyes and several minor differences seemed to make the determination doubtful. On June 10, 1926, Mr. F. H. Walker collected a male at Danvers, Mass., but from the description I was still doubtful. In June, 1928, Dr. J. P. Bill took a female at Wayland, Mass. On June 16, 1928, I collected a female at East Gloucester, Mass. On June 14 and 17, 1929, I again visited the same place, near Braces Cove, East Gloucester, and captured twenty-one specimens, including three males. Most of the specimens were taken on the flowers of the tall buttercup *(Ranunculus acris).* On June 16, 1929, Mr. Nathan Banks took a female at Hollis-ton, Mass.

I now felt sure that these were the males and females of *Chilosia hiawatha,* notwithstanding the sexual differences and discrepancies in the original description. To make sure, however, I submitted a male to Mr. Charles T. Greene of the U. S. National Museum, pointing out some of the characters not clearly defined in the description, and received the following note based on the type.

"The 'central, longitudinal groove' is in the frontal triangle (not the ocellar triangle) ; the halter is pale luteous with a brownish infuscation at the base of the stem

[1]A Revision of the Chilosini. By Raymond C. Shannon Insec. Inecit., vol. 10, pp. 47-145.

and a brownish spot on the knob. Abdominal pile long and yellow, under side of all tarsi with yellowish pubescence; joints 2, 3, and 4 of front tarsi are slightly more brownish in the type than in your specimen. Your specimen is slightly smaller than the type, but otherwise it is identical."

The female has the eyes bare; the third joint of the antennae is often more brownish than in the male; the front, about one-fifth the total width of the head, is black, shining, with three slight grooves; lower parts of the orbits whitish pubescence. The 2nd, 3rd, and 4th joints of the front tarsi are often darker than in the male the latter being often decidedly yellow. The pile on the abdomen short and oppressed. Wings more yellowish at the base and the knobs of the halters entirely yellow. The species vary from 9 to 10 mm.

Becker restricted the genus Chilosia to those species having hairy eyes and antennal pits. Those with bare eyes and with the antennal pits confluent were placed in the genus Cartosyrphus Bigot. Shannon says: "Unfortunately the type species of Chilosia, *flavipes*, has the eyes sometimes bare in the female, but the writer believes that this species will be found to have the anntennal pits separated which would put the genus Chilosia on a better basis."

If the narrow oblique impressed lines extending from the base of the antennae to the orbits, can be called antennal pits, then this species could be referred to Chilosia, otherwise it would be difficult to separate the female from species of Cartosyrphus which have similar oblique impressed lines. The genus Cartosyrphus seems to stand on very weak characters.

A NEW THYNNID WASP FROM NEW CALEDONIA.

By T. D. A. Cockerell.

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On the occasion of our recent (1928) visit to New Caledonia, my wife and I collected many interesting insects, but perhaps none more interesting than a wasp of the family Thynnidæ now described.

Eirone superstes n. sp.

♂. Length about 12 mm.; slender, variegated with black, red and yellow, the surface shining; head rather thick, circular seen from in front, the orbits slightly diverging below; clypeus, rather broad bands along inner orbits, and mandibles except apex, yellow flushed with red, the mandibles ferruginous subapically, very stout, with a long oblique cutting edge, and a small but well defined inner tooth; clypeus obtusely angulate in middle, both it and the mandibles furnished with long glistening yellowish hairs; maxillary palpi brown, slender, the three last joints subequal, and decidedly elongated; front shining with few scattered punctures; ocelli in a high triangle; cheeks with a yellow band behind the eyes, ending about two-thirds of the way up, but behind this a broad pale red area, which sends a pointed projection far up on the occiput; antennae slender, long enough to reach metathorax, the scape reddish yellow in front, the flagellum black; a pair of large tubercles just above and between antennae bright yellow; thorax black marked as follows: a yellow marginal band on prothorax briefly broken sublaterally; crescentic yellow mark just in front of tegulæ; large rather footshaped yellow area, suffused with red, on mesopleura; two reddish-yellow stripes

on hind part of disc of mesothorax; large yellow spots on axillæ; scutellum and postscutellum pale yellowish red; the bulging impunctate metathorax pale ferruginous; parapsidal furrows deep; tegulæ testaceous with a large yellow spot; wings strongly reddened, blackish at apex; stigma and nervures dull ferruginous; second cubital cell with sloping sides, but still very broad above, receiving recurrent nervure at middle; third cubital receiving second recurrent far from base, but distinctly before middle; anterior coxæ red in front, the coxæ otherwise black; femora, tibiae and tarsi entirely bright ferruginous; abdomen narrow, subcylindrical, the margins of the segments with stiff black hairs, but apex with thin pale hair; first, fifth and sixth and base of seventh segment black above and below; second, third, fourth, and apical segment except base bright orange-ferruginous above and below; apex truncate, unarmed.

New Caledonia: Bourail, May 22 (W. P. Cockerell). Type for the present in my collection. Allied to *E. obtusidens* Turner, 1919, from Noumea, New Caledonia. Dr. James Waterston kindly examined the type of *E. obtusidens*, in order to confirm certain points of distinction. He reports as follows:

(1) Clypeal hairs. The longest and strongest blackish brown, the finer ones, especially those near edge, much paler.

(2) Clypeus with nearly straight edge, but in the middle one fourth or one-fifth produced into a blunt triangular tooth.

(3) Anterior coxæ shining black.

(4) Abdomen with only tergites 2 to 4 reddish; sternites are black or blackish.

(5) Apex of abdomen; tergite black, with reddish bristles, sternites narrowly reddish edged at apex.

(6) Abdominal tergites 2 to 5 fringed with short stiff black bristles, on 2 to 4 these bristles extend beyond the

hind edge about one-third of their length, on 5 to nearly half, i. e., relatively longer.

(7) Apical joints of maxillary palpi are in my opinion elongate, the last obviously a little more slender than the penultimate.

Dr. Waterston thinks Turner's species is probably correctly placed in *Eirone,* but the abdomen is a little unusual. The characters of the mandibles, clypeus and palpi may perhaps be considered to indicate at least a distined subgenus. My species is allied to Turner's, but evidently distinct.

In 1922 Montet described a *Spilothynnus thalluse,* said to occur in New Caledonia. Miss Sandhouse has kindly copied the description for me, and I find that the species was based on two females, 8.5 mm. long, one said to be from Australia, the other from New Caledonia. There is apparently no history with either, and Montet remarks that there may be an error in the indication of localities. The Australian specimen, of which details are figured, is herewith designated as the type. *Spilothynnus* is a South American genus with spotted abdomen.

If we disregard Montet's species as too uncertain, it still remains true that New Caledonia has two species of Thynnidæ which are endemic, and abundantly distinct from anything known in Australia. There is also a Mutillid *(Mutilla caledonica* André), found at Noumea in New Caledonia.

These Hymenoptera, having wingless females, are doubtless relics of ancient continental connections, probably north-westward. There are Thynnidæ in New Britain, the Solomon Is. *(Thynnus barbarus* Turner), New Guinea, the Aru Is., Ceram, Celebes, and north to the Philippine Is. *(Thynnus luzonicus* Turner; *T. bakeri* Rohwer). There is a species *(Rhagigaster novaræ* Sauss.) said to come from New Zealand, but Tillyard in his recent work credits none to that country. *Eirone* has 33 known species, in addition to the two from New Caledonia. With the exception of the latter, it is strictly an Australian genus.

The Thynnidæ, also well represented in South America, illustrate the discontinuous distribution of ancient groups; and the fact that the New Caledonia species can be placed (if not quite comfortably) in an Australian genus indicates the great antiquity of the general type. The family is probably as old as the mesozoic. New Caledonia has doubtless, during its long history, experienced many changes of level, and there are reasons for thinking that it has at times been reduced to a much smaller area, and at other times connected with the Loyalty Islands, which have a very similar fauna. West and South of New Caledonia is a great submarine bank, extending to New Zealand, and including near its western edge Lord Howe Island. In Lord Howe Island we have a very remarkable assemblage of land snails, including the genus *Placostylus* and (as Mr. T. Iredale pointed out to me) *Platyrhytida;* characteristic New Caledonia genera. North of Lord Howe Island are reefs dangerous to shipping, representing former islands. As we passed one of them, on which the wreck of a large vessel could be seen, it was impossible to avoid a feeling of disappointment at the loss of the interesting fauna and flora which must have flourished there in early times. Even in Lord Howe Island, where so many interesting relics survived, the fauna is rapidly disappearing as the result of the accidental introduction of rats.

I have recently described a bee *(Paracolletes philonesus* Ckll.) collected by A. R. McCulloch on Lord Howe Island, and now in the Australian Museum. It belongs to an Australian genus, which also occurs in New Zealand, but not in New Caledonia. The female is about 9.5 mm. long, and runs in my table near *P. metallescens* Ckll. but has the abdomen dull, not metallic, hardly punctured. The wings are brownish; second cubital cell broad at base, greatly contracted above. It may be that *Paracolletes* will yet be found in the mountains of New Caledonia; in Australia it is richly developed in the temperate portion, but there is a small species *(P. tropicalis* Ckll.) on Melville Island, off the north coast.

THE NESTING HABITS OF THE BURROWING BEE, *EPINOMIA TRIANGULIFERA* VACHAL[1]

By Phil Rau,

Kirkwood, Mo.

Epinomia triangulifera is a large bee, recorded heretofore, according to W. Dwight Pierce[2], from New Mexico, Kansas and Nebraska. In St. Louis it was found in large colonies on two clay hillocks in a vacant lot comprising a few acres in the heart of the city. These bees seem to have a strange liking for elevated areas, for in this sunny region, which was a favorite haunt of so many Hymenoptera, only these two colonies on the hillocks were found. For want of a temporary name, I called them the "knoll-bees," and was much interested to find that Mr. Pierce had been impressed with the same characteristic, for he also records having found them in colonies and on elevations "a foot or so above the surrounding ground."

On the gentle slope of a knoll, a few nests of this species were seen during the warmer months of three years. On September 1 of the fourth year, 1918, when this spot was examined, they were found in enormous numbers. The conditions which obtained in that place or year must have been exceptionally favorable to this species, in order to produce so many. The most densely populated portion was the area sloping gently toward the southwest, although the level portions of the hill-top were also abundantly occupied. This region was covered with grass of a wiry nature, growing sparsely on the clay soil, with occasional patches entirely barren. Both amidst the grass and on the uncovered areas their domes of excavated earth were to be seen; in

[1] Identified by J. C. Crawford.
[2] Univ. Nebr. Stud. 4: 29. 1904.

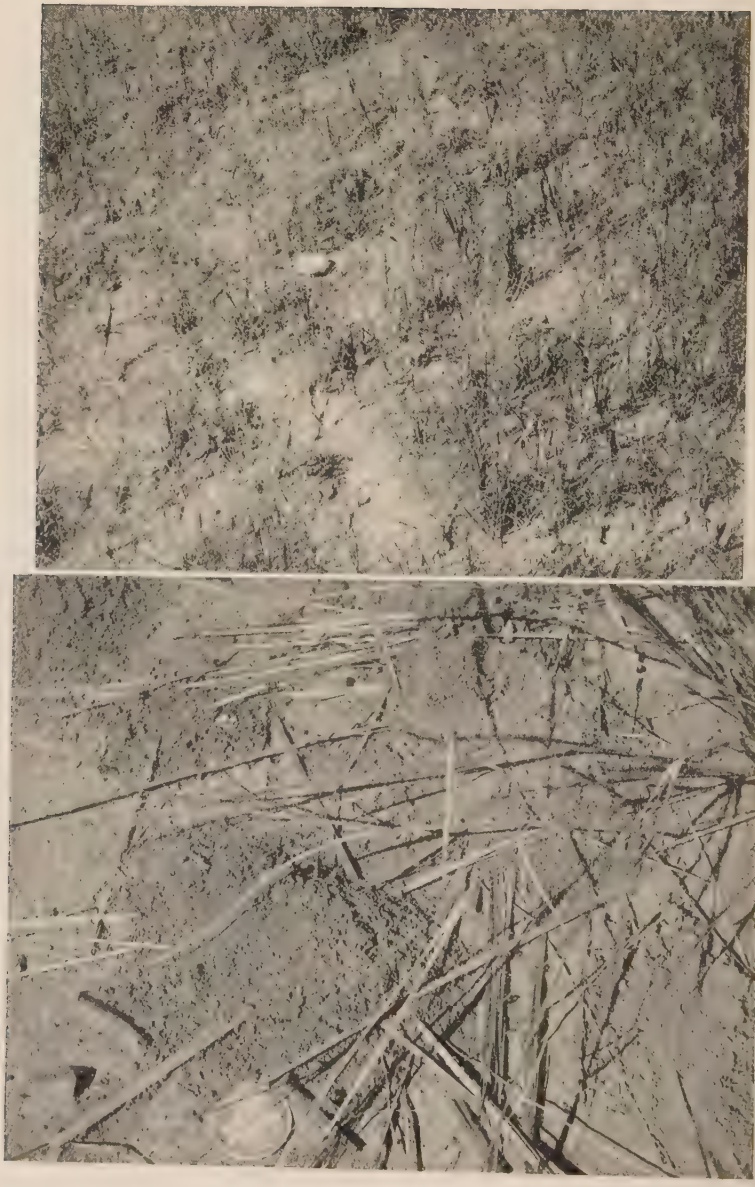

Fig. 1. Nesting Site of the Knoll-bee, *Epinomia triangulifera.*
Fig. 2. Nests of Knoll-bee.

the grassy areas the vegetation helped to anchor the loose soil and hold the little hills intact over their burrows. Figure 1 shows their domes among the sparse grass.

In another area, perhaps a hundred yards away, on a plateau left by the artificial cutting down of a high embankment, they also occurred in great abundance in that year. This plateau, about six feet above the surrounding surface, had a slight southward slope, the same as the first locality. The population of bees inhabiting this small elevation was of especial interest. Four years previously, in the early spring, this embankment had been graded down and the yellow clay hauled away for use elsewhere. Every season thereafter, I frequently scanned the newly exposed soil of this plateau in search of data upon the succession of insect life that would take possesssion of it. The first and second summers gave no vegetation, (this suggests how heavy and impenetrable was the soil, if even seeds and grasses could not take hold upon it), and besides a few turret spiders, grasshoppers and cicindela beetles, nothing was seen to nest upon it. In the third year, the parent stock of the present population migrated thither from the other knoll one hundred yards to the north. Considering the enormous increase and the flourishing condition of this immigrant population, we are justified in concluding that the conditions which characterized this spot must have been precisely to their pleasure and advantage, and therefore we may justly accept this as their characteristic habitat, although we have seen them in only few localities. Especially on the northern portion of this plateau, in an area about twenty-five feet square, the nests were so abundant that one could not step anywhere without trampling upon them. In fact, it often happened that three to five nests were so close together as to have one large, spreading mound to cover them all, and in one area only one yard square, I actually counted two hundred and sixty nests of these bees. Figure 2 shows seven nests and a coin (American ten-cent piece) to show the relative size. The task of digging must have been great in this heavy clay, for the amount of soil was enormous. When one looks upon the work of a colony of these bees, one cannot help thinking that they, like the earth-

worms, are active agents in working over the soil.

The openings into the burrows are not exposed, but each is completely covered by its mound of loose soil. Sunflowers abounded in this region, and the returning bees were heavily laden with golden pollen, not only on the legs, but on the under side of the abdomens as well. Close examination of specimens later revealed that there were rows of hairs on the abdomen and legs, the purpose of which is readily apparent.

A returning bee has little difficulty in finding her burrow, and alights upon it without hesitation or orientation. She does not kick away the soil to make an opening as do certain wasps; in fact, I doubt if her heavily laden condition would permit her to do so, but she immediately pokes her head into the loose soil of the mound, and with a few mysterious pushes, wriggles through somehow, without for an instant uncovering the burrow.

On September 1, the date when I discovered the large population in 1918, the mounds were inspected at noon, but, although they were watched for an hour, no life was seen about them. At three o'clock when I returned, many of the bees were on the wing bringing in pollen. A few were not so laden, but out of about one hundred counted in one area, only three were seen returning to the nest empty-handed; however these might have been still occupied with burrowing. One nest was opened after one of these unladen mothers had entered; the digging was indeed a task, for the yellow clay was gummy and unyielding. The burrow was $\frac{3}{8}$ inch in diameter, and went down straight into the ground for 17 inches. In the bottom was the mother bee, but no cell was there: the burrow was not yet quite ready for pollen. I was not at hand when the excavating was going on, but, as mentioned before, they work close together in a small circumscribed area, and they may possibly use for nidification the burrows from which they emerge.

It rained all of September 2, and when I examined the nests the next day, I found that all the little hills of loose soil had been washed smooth and packed down over the nests, and the openings had not yet been uncovered. One bee

with her heavy load of pollen was trying to effect an entrance to one of the holes. Whether she had been away from home during the storm and was just now returning, I do not know. The following night it rained again, and my next examination three days later, showed that they were making but slow progress in resuming activities; scarcely more than one-tenth of them had then been able to escape from their temporary imprisonment. From this it is at once apparent that rains are really a serious impediment to the work of this species, even more than we see in the cases of some of the burrowing wasps, as *Bembix mubilipennis* and others, which scramble out uninjured almost as soon as the storm-clouds have blown away. May there be some correlation between this greater liability to injury in heavy rains and their habitual choice of high knolls for nesting sites? In three or four places on the ground were little masses of pollen which the females had lost in their extreme efforts to gain entrance to burrows closed by the rain.

The next day the sun shone and there was a slight increase in activity, but in some portions of the field it appeared that there had been heavy mortality. On this occasion I made one more attempt at digging up nests. In following one, it was necessary to dig out a space about a foot across, and in so doing I broke into five other nests. I could follow only one of these channels, however; it went straight down for 24 inches, and the worker was at the bottom. Three inches above the terminus was a lateral cell filled with golden pollen and containing a very young larva.

In the area of the colony where the hill-top had recently been cut away, the nests occured in abundance on the top and some were very close to the edge of the sharp declivity, but there were none at all on the steeply sloping side. Since all of the burrows went straight down, some of the nests near the edge, although they were placed at a proper depth below the top, had very little protection of soil on the side.

By September 12, the nests had almost regained their normal proportions, and one could hardly see that the rains had played havoc. The great majority of the bees had been able to dig out of their temporary prisons. When I visited

Bee-city the next morning at nine o'clock, I was surprised to find almost all nests wide open and heavily laden mothers entering them. These bees made no effort to keep the holes closed either in their absence or presence as they had so constantly done before, probably because the soil had been washed away. Only a few nests were still covered; perhaps these contained lazy or sleepy bees. This was my first visit to the colony so early in the morning. The afternoons had always found the nests covered, and likewise on this day, at five o'clock the holes were all covered as usual, with the exception of perhaps a half-dozen which had probably lost their proprietors through disaster. The problem remains whether they close them to exclude the mid-day heat, or open them for a morning airing, or for some other reason. One frequent reason for closing or guarding the entrance to wasp or bee burrows is the annoyance of parasites. The only enemies observed lurking about here were a few *Philanthus puctatus* females, but they were not actually seen to enter the holes. These wasps seek bees for prey, but I am very doubtful that they would venture to attack healthy bees three times as large as themselves.

Thus they flourished in bliss unalloyed for a few days until the next rainy spell came in the latter part of September. Meanwhile their progress in provisioning their cells must have been great, for the surrounding region was full of sunflowers and autumnal composites, which brought their supplies of food near to hand. Great quantities of white snakeroot also grew near by, but I did not at any time see the bees carrying white pollen, although in two or three cases they were seen feeding upon the flowers.

The autumn rains again flattened the mounds of the knoll-bees and covered the burrows with sticky clay as before, and caused a permanent stoppage of activities. Days passed, and I waited for them to reappear, but they did not. Either they were so old that they could not again dig themselves out, or this late date practically marked their threescore and ten. A very, very few stragglers were seen later, but in the few nests which were excavated each was the tomb of its maker.

STYLOPIZED VESPIDÆ[1]

By George Salt[2] and Joseph Bequaert[3]

It is becoming increasingly difficult to prepare a complete account of the various insects infested with Strepsiptera. Many of the early writers on these parasites gave lists of hosts without stating definitely whether they had themselves seen stylopized specimens or whether their records were copied from earlier workers. Taxonomists have mentioned infested specimens in monographs of various host groups, so that many records have become scattered in articles not at all concerned with the parasites, where they are likely to be found only by a student of the hosts. Mistakes in the identification of host species have caused much confusion; and the change of names, which seems inevitable in taxonomic revision, has greatly complicated the existing lists.

As one of us (J.B.) has been for a number of years interested in the Vespidæ, while the other (G.S.), in the course of studies on stylopization, has found it necessary to keep lists of stylopized wasps, we have thought that it would be useful to publish jointly an annotated list of the Vespidæ known to be infested with Strepsiptera. From the data contained in our list we have been able to draw several conclusions which are of some interest and importance to the general subject of the inter-relation of parasite and host.

We have examined stylopized material mainly from the Academy of Natural Sciences of Philadelphia, the American Museum of Natural History, the Boston Society of Natural

[1] Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 305.

[2] Department of Tropical Medicine, Harvard University Medical School.

[3] National Research Fellow in Zoology, 1927-1928.

History, the Canadian National Collection, Cornell University, the Museum of Comparative Zoölogy, and the United States National Museum; and from the personal collections of Mr. Charles Robertson of Carlinville, Illinois, Dr. C. H. Kennedy of Ohio State University, and Dr. W. M. Wheeler of the Bussey Institution, Harvard University; as well as that which we had in our own possession. We have been particularly fortunate in being able to study the stylopized specimens accumulated at the United States National Museum by Dr. W. D. Pierce and thus to connect our own identifications and records with his extensive lists. To the authorities of these institutions and to the workers who have so kindly lent or given us material, we are very grateful.

In the following list valid records are given in heavy face type, synonyms or records based on misidentifications in italics. References cited only once are given in full in the text, those used in several instances are placed in the bibliography. The words "male" or "female" invariably refer to the host, the signs ♂ or ♀ to the parasite. ♂e represents the exuvium of a male Strepsipteron, ♂p the puparium of the same. We record the position of the parasite by giving the number of the abdominal tergite under which it is found and the letter "R" or "L" for the right or left side respectively. In the few cases in which the parasite was situated under a sternite rather than a tergite, the letters "st" follow the number of the segment. The other abbreviations are self-explanatory. Needless to say, our re-assignment of host records, in particular those of Pierce, is based upon an examination of the specimens in question.

List of the Known Vespid Hosts of Strepsiptera

Masaridinæ

Paragia decipiens Shuckard. Smith, 1867, Proc. Ent. Soc. Lond. (3) 5, lxxxviii: Gawler River, Adelaide, South Australia; ♂e. Kriechbaumer, 1874, Stettin Ent. Zeit. 35, 254: South Australia; six males and three females. Oglobin, 1923, Sbornik Ent. Odd. Narod. Mus. Prague

1, 46: Gawler, South Australia; Odewahn; ♂ and ♀ of *Paragioxenos brachypterus* described. Hofeneder, 1928, Societas Entom. 43, 46: Gawlertown, Australia; male, ♀-4R. ♀ *Paragioxenos brachypterus* Ogl. Hofeneder, ibid. p. 48: Flasun, Australia; 1872; male, ♂ e.

New record: New South Wales; female, ♂ e-3L, ♂ e-3L, ♂ e-3R, ♂ e-4R (A.M.N.H.).

Paragia tricolor Smith. Saunders, 1872, 42: Australia; ♀. This may have been either the true *P. tricolor* Smith or *P. smithii* Sauss.

Raphiglossinæ

Psiliglossa odyneroides Saunders. Saunders, 1872, 42: Epirus; ♂ p.

Zethinæ

Zethus pubescens Smith. Salt, 1927, 183: Mfongosi, Zululand; Dec. 1911; W. E. Jones; female, ♂ p-4L.

Zethus romandinus Sauss. New record: Iquitos, Peru; 27 July to 7 Aug. 1920; Cornell Univ. Exped.; female, ♀-3L, ♂ e-4R.

Zethus spinipes Say var. **variegatus** Sauss. Salt, 1927, 183: Dallas, Texas; Jacob Boll; female, ♀-4R; and female, ♀-4R (both M.C.Z.).

New record: Gainesville, Alachua Co., Florida; 23 April 1923; Alexander and Walker; male, ♂ e-4R (U.S.N.M.).

Eumeninæ

Eumenes arcuatus (Fabr.) var. **praslinius** (Guérin). Pierce, 1918, 489 (as *E. flavopicta* Blanchard): Larat; F. Muir; ♀, ♂ p, ♂ e, and triungulinids.

New record (probably one of above specimens): Larat; male, ♂ e-4R (U.S.N.M.).

Eumenes campaniformis (Fabr.) var. **higletti** Meade-Waldo. Salt, 1927, 183 (as *E. campaniformis* var. *marshalli* Bequaert): Salisbury, S. Rhodesia; Dr. Melle Arcturus; male.

Eumenes campaniformis (Fabr.) var. *marshalli* Bequaert. Salt, 1927, 183:=*E. campaniformis* var. *higletti* Meade-Waldo.

Eumenes campaniformis (Fabr.) var. **rendalli** Bingham. New record: Boma, Congo; 16 June 1915; Lang and Chapin; female, ♂ p-4R (A.M.N.H.).

Eumenes fenestralis Sauss. See *E. maxillosus* var. *fenestralis* Sauss.

Eumenes flavopicta Blanchard. Pierce, 1918, 489: in error for *E. arcuatus* var. *praslinius* Guérin.

Eumenes fraternus Say. Salt, 1927, 183: Forest Hills, Mass.; 19 Aug. 1926; George Salt; male, ♀-3R.

Eumenes harmandi Pérez. New record: Chas Yang, Chili, China; 11 July 1921; A. P. Jacot; male, ♀-3R (U.S.N.M.).

Eumenes maxillosus (Degeer). Heyden, 1867, 398 (as *E. tinctor* Christ): Abyssinia; ♀.

New records: Matadi, Congo; 9 June 1915; Lang and Chapin; female, ♀-3L (A.M.N.H.). Boma, Congo; 17 June 1915; Lang and Chapin; male ♂ p-4R (A.M.N.H.).

Eumenes maxillosus (Degeer) var. *circinalis* (Fabr.). Salt, 1927, 183=*E. pyriformis* var. *circinalis* (Fabr.).

Eumenes maxillosus (Degeer) var. **conicus** (Fabr.). New record: Bangkok, Siam; 18 April 1926; H. M. Smith; female, ♀-3R, ♀-3L (U.S.N.M.).

Eumenes maxillosus (Degeer) var. **fenestralis** (Sauss.). Heyden, 1867, 398: Abyssinia; ♀.

New record: Boma, Congo; 29 June 1915; Lang and Chapin; male, ♂ e-3L (A.M.N.H.).

Eumenes maxillosus (Degeer) var. **reginus** (Sauss.). Salt, 1927, 183: Diego Suarez, Madagascar; female.

Eumenes melanosoma Sauss. var. **æthiopicus** (Sauss.). New record: Kakatown, Liberia; Aug. 1926; J. Bequaert; male, ♀-3L.

Eumenes petiolata (Fabr.). Smith, 1859, 130:= *E. pyriformis* Fabr.

Eumenes pomiformis (Rossi). Saunders, 1872, 42: Nicæa; ♂ p.

Eumenes pyriformis Fabr. Smith 1859, 130 (as *E. petiolata* Fabr.) : India; female, ♀-3, ♂ e-4.

Eumenes pyriformis Fabr. var. **circinalis** Fabr. Salt, 1927, 183 (as *E. maxillosus* var. *circinalis* Fabr.) : Amboina, Moluccas; Rouyer; female.

New record: Trong, Lower Siam; W. L. Abbott; female, ♀-3R, ♀-3L; and female, ♀-3L (both U.S.N. M.).

Eumenes tinctor Christ. Heyden, 1867, 398:=*E. maxillosus* (Degeer).

Odynerus (See also Pachodynerus and Ancistrocerus).

Odynerus sp. Smith, 1859, 130: Brazil; female, ♂ p-3. Pierce, 1918, 489: Tucson, Arizona; 24 Aug. 1913; W. D. Pierce; ♀-3, ♀-4.

Odynerus annulatus Say. Pierce, 1909, 180: Dallas, Texas; 31 July; W. A. Hooker; ♀. Salt, 1927, 183: Austin, Texas. New Braunfels, Texas. Custer County, Dakota; S. W. Garman.

New records: Montana; female, ♂ p-5R (A.N.S.P.). New Mexico; female, ♀-4L (A.M.N.H.).

Odynerus anormis (Say). Robertson, 1910, 325: Carlinville, Illinois; 31 May, 29 Oct., Chas. Robertson. Salt, 1927, 183: Carlinville, Illinois; Chas. Robertson.

New record: Colorado; C. F. Baker; male, ♀-3R (U. S.N.M.).

Odynerus arvensis Sauss. Robertson, 1910, 325: Carlinville, Illinois; 2 Aug.; Chas. Robertson. Pierce, 1911, 499: from above specimen describes ♀ of *Pseudoxenos arvensidis*. Pierce, 1918, 489 (as *O. firmus* Cresson): Cedar Point, Ohio; 19 June 1913; J. B. Parker; ♀. Salt, 1927, 183: Carlinville, Illinois; Chas. Robertson; male, ♂ p-4R (M.C.Z.).

New records: Put-in-Bay, Bass Island, Ohio; 1-10 July; C. H. Kennedy; female, ♀-4L. Texas; female, ♀-3L, ♀-4R (A.N.S.P.).

Odynerus ater (Sauss.). Schultze, 1925, Phil. Journ. Sci. 27, 235: Manila, Philippine Islands; Oct. 1924; W. Schultze; male, ♀-3R, ♀-3L, ♂ p-4R, ♂ p-4L; male, ♂ p-4L; wasp, ♂ p-4; and wasp, ♀-3. ♂ and ♀ of *Macroxenos piercei* described (as *Rynchium atrum* Sauss).

Odynerus bellulus Cresson. Salt, 1927, 183: Lee County, Texas; G. Birkman; male.

Odynerus bermudensis Beq. New record: Bermuda; Sept. 1925; L. Ogilvie; female (holotype), ♀-4R (Brit. Mus.).

Odynerus bifurcus Rob. Robertson, 1910, 325: Inverness, Florida; 3 March; Chas. Robertson.

New record (may be same specimen as above): Inverness, Florida; 3 March; Chas. Robertson: Male, ♂ p-4L (U.S.N.M.).

Odynerus blandus Sauss. Salt, 1927, 183: Stanford University, California.

Odynerus chloroticus Spinola. Heyden, 1867, 398: Abyssinia; ♀.

Odynerus colon Cresson. Pierce, 1909, 180: in error for *Ancistrocerus fulvipes* (Sauss.).

Odynerus crenatus Lepel. Monod, 1925, Bull. Soc. Zool. France 50, 230: Sierra Morena, Spain; A. Seyrig; female, ♂ p-3-L, ♂ p-4L, ♂ p-5R; and female, ♀-3R, ♂ e-5R. ♂ and ♀ of *Pseudoxenos seyrigi* described.

Odynerus dantici (Rossi). New record: Dalmatia; male, ♀-3R (A.N.S.P.).

Odynerus deflendus (Saunders). Saunders, 1853, 141: Epirus and Corcyra; male; June to Aug.; ♂ and ♀ of *Pseudoxenos heydenii* described.

Odynerus figulus Sauss. New record: Sanchez, Rep. Dominicana; 11-16 May 1915; male, ♀-3R (A.M.N.H.).

Odynerus firmus Cresson. Pierce, 1918, 489: in error for *O. arvensis* Sauss.

Odynerus flavomarginatus (Smith). Smith, 1852, Trans. Ent. Soc. London (2) 2, pt. 1, 35 (as *Rhynchium flavomarginatum* Sm.): Northern China; male; 2 ♀-3. S. Saunders, 1872, 42. Pierce, 1909, 180.

Odynerus flavopictus Sauss. New record: Put-in-Bay, Bass Island, Ohio; 1-10 July; C. H. Kennedy; male, ♂ e-3L, ♂ e-4R; female, ♂ e-4R; and male, ♀-4R. Falls Church, Virginia; 2 June; N. Banks; male ♂ e-5R (M.C.Z.).

Odynerus foraminatus Sauss. Pierce, 1909, 180: Cincinnati, Ohio; 10 Aug.; ♀. Robertson, 1910, 325: Carlinville, Illinois; 13 Aug.; Chas. Robertson. Pierce, 1911. 506: Trenton, New Jersey; 5 July 1907; ♀ of *Pseudoxenos foraminati* described p. 499. Salt, 1927, 183: Woods Hole, Massachusetts; male, ♀-4L; female, ♀-4L, ♀-4L, ♀-4R; and male, ♂ p-4L. Carlinville, Illinois; Chas. Robertson; female, ♀-4L (M.C.Z.). Chicago, Illinois; female, ♀ p-5R; male, ♂ e-4L; and male, ♀-4L. Philadelphia, Pennsylvania; 23 Aug. 1900; female, ♀-4L. Dallas, Texas; J. Boll; female, ♀-3R, ♀-3L, ♀-4R (M.C.Z.). Fedor, Texas; 11 May; G. Birkman; male, ♀-3R (M. C.Z.). West Jefferson, Ohio; 26 Aug. 1923; J. Bequaert; female, ♂ p-5R. Vienna, Virginia; 18 Aug.; male, ♀-4R. Dyke, Virginia; 14 May; N. Banks; male, ♂ p-4L (M. C.Z.). Falls Church, Virginia; N. Banks.

New records: Nyack, New York; 2 July 1884; female, ♀-4L (A.M.N.H.). Pennsylvania; male, ♂ p-4R (U.S.N.M.). Put-in-Bay, Bass Island, Ohio; July; C. H. Kennedy; female, ♂-3R, ♀-3L; female, ♀-3L, ♀-4R; female, ♀-4L; female, ♀-4L; and female, ♀-4L. Lawrence County, Ohio; 23 Aug. 1926; C. H. Kennedy; male, ♀-4R. Texas; male, ♀ 4R (A.N.S.P.). Texas; 5 May 1900; male, ♀-4R.

Odynerus fundatiformis Robt. Robertson, 1910, 325: Orlando, Florida; 17 Febr.; Chas. Robertson.

Odynerus fundatus Cresson. Robertson, 1910, 325: Carlinville, Illinois; 25 June, 19 July; Chas. Robertson.

Pierce, 1911, 506: Carlinville, Illinois; 25 June; Chas. Robertson; ♀ of *Pseudoxenos fundati* described p. 500. Salt, 1927, 183: Austin, Texas. Carlinville, Illinois; Chas. Robertson.

Odynerus fusus Cresson. New record: Texas; female, ♀ 13R, ♀-3L; female, ♀-3R; and male, ♀-3R (all A.N.S.P.).

Odynerus hæmorrhoidalis (Fabr.). New record: Buitenzorg, Java; March 1909; Bryant and Palmer; female, ♀-3L (U.S.N.M.).

Odynerus hidalgi Sauss. Pierce, 1909, 181 (as *O. verus* Cresson): Dallas, Texas; 21 July; W. A. Hooker; male, ♀ of *Pseudoxenos hookeri* described p. 139 (U.S.N.M.).

Odynerus japonicus (Dalla Torre). New record: Kyoto, Japan; female, ♀-3L (A.N.S.P.).

Odynerus lævipes Shuckard. Saunders, 1853, 142 (as *O. rubicola* Dufour): Epirus; ♂ of *Pseudoxenos klugii* described.

Odynerus leprieurii Spinola. Spinola, 1841, 128:= *Montezumia leprieurii* (Spinola).

Odynerus leucomelas Sauss. New record: Queen's Park, Aylmer, Quebec; 15 Aug. 1924; C. B. Hutchings; female, ♀-4L (Can. Nat. Coll.).

Odynerus manifestus Cresson. Salt, 1927, 184:= *O. primus* Dalla Tore.

Odynerus megæra Lepel. New record: Florida; female, ♂ e-4R, ♂ e-4L (Can. Nat. Coll.).

Odynerus molestus Sauss. Dury, 1902, 180: Cincinnati, Ohio.

Odynerus pedestris Sauss. Robertson, 1910, 325: Carlinville, Illinois; 6 July; Chas. Robertson. Pierce, 1911, 500: from above specimen describes ♀ of *Pseudoxenos pedestridis.*

Odynerus perennis Sauss. Salt, 1927, 184: Great Falls, Virginia; 9 Sept.; N. Banks; male, ♀-3L (M.C.Z.). Dyke, Virginia; 14 May; N. Banks; male, ♂ p-4L (M.C.Z.).

Falls Church, Virginia; 27 June; N. Banks; female, ♀-3L (M.C.Z.).

Odynerus pratensis Sauss. Salt, 1927, 184: El Paso, Texas; female.

Odynerus primus Dalla Torre. Salt, 1927, 184 (as *O. manifestus* Cress.): Fedor, Texas; female.

Odynerus rubicola Dufour. Saunders, 1853, 142:= *O. lævipes* Shuckard.

Odynerus spinipes (Linn.). Saunders, 1872, 46: Corcyra; 22 May; ♂ of *Pseudoxenos corcyricus* described.

Odynerus sulphureus Sauss. New record: Baron, California; female, ♀-3R, ♀-3R, ♀-4L (U.S.N.M.).

Odynerus synagroides (Sauss.). New records: Stanleyville, Belgian Congo; 15 March; female, ♀-2L, ♂ e-4L; and male, ♂ p-3L (both A.M.N.H.). Coquilhatville, Belgian Congo; 15 October 1922; J. Bequaert; male, ♂ e-5L.

Odynerus toas Cresson. Pierce, 1918, 489: Albuquerque, New Mexico; ♂ of *Pseudoxenos neomexicanus* described p. 463. Salt, 1927, 184: Valentine, Texas; male. El Paso, Texas, male. Steins, New Mexico; male.

Odynerus turpis Sauss. Robertson, 1910, 325: Inverness, Florida; 19 March; Chas. Robertson.

Odynerus vagans Sauss. Pierce, 1909, 181: Mound, Louisiana; 12 May; C. R. Jones; ♀ of *Pseudoxenos louisianæ* described p. 138.

Odynerus verus Cresson. Pierce, 1909, 181: in error for *O. hidalgi* Sauss.

Odynerus ziziæ Robt., mss. Robertson, 1918, Bull. Brooklyn Ent. Soc. 13, 85.

Rhynchium (See Odynerus).

Pachodynerus cubensis (Sauss.). Salt, 1927, 184: Soledad, Cuba; April; J. Bequaert; male, ♀3R, ♀-4L, ♀-4stL, ♂ e-5R (♂ emerged in captivity).

Pachodynerus erynnis (Lepel.). Robertson, 1910, 325: Inverness, Florida; 10 Febr., 10 and 25 March; Chas. Robertson. Pierce, 1911, 506: Inverness, Florida; Chas. Robertson; ♀ of *Pseudoxenos erynnidis* described p. 499. Salt, 1927, 184: Lakeland, Florida; Wm. T. Davis. Inverness, Florida; Chas. Robertson. Miami, Florida; J. Bequaert.

New records: Inverness, Florida; Chas. Robertson; female, ♀-3L; male, ♀-3R, ♀-3L; male, ♀-2R, ♀-2L, ♂e-4R, ♂e-4L; and male, ♀3R, ♀-3L (all M.C. Z.). Punta Gorda, Fla.; 11 Nov. 1911; female, ♂p-3R, ♀-3L, ♀-3stL, ♂p-4L, ♀p-4R (A. M. N. H.). Royal Palm Park, Florida; 12-18 April 1923; male, ♀-4R (A.M.N.H.). Miami, Florida; 18 Dec. 1912; F. Knab; female, ♀-3L, ♂p-4R (U.S.N.M.).

Pachodynerus guadulpensis (Sauss.). Salt, 1927, 184: Santeurs, Grenada; Sept. 1910; Allen and Brues; female, ♀-3R.

Pachodynerus nasidens (Latr.). Salt, 1927, 184: Puerto Castilla, Rep. Honduras; J. Bequaert.

New record: Ypiranga, R. Iga-Putumayo, Brazil; 29 Aug. 1920; Cornell Univ. Exped.; female, ♀-2L, ♀-3R.

Pachodynerus præcox (Sauss.). New record: St. Benedict Mt., Tunapuna, Trinidad; 3 Sept. 1927; M. G. Netting; male, ♀-3R, ♂p-4L.

Pachodynerus punctulatus Brèthes. New records: Iguazu Falls, Argentina; 20-22 Jan. 1920; Cornell Univ. Exped.; female, ♀-3L, ♂e-4L, ♂e-4R. Paso de 1. Libres, Corrientes, Argentina; 12-14 Jan. 1920; Cornell Univ. Exped.; female, ♂p-4L, ♀-4R.

Ancistrocerus sp. *(auctus* (Fabr.)?) [*A. auctus* (Fabr.)= *A. parietum* (Linn.)]. Heyden, 1836, lxxiv: ♂.

Ancistrocerus albophaleratus (Sauss.). Pierce, 1911, 506 [as *A. capra* (Sauss.)]: Washington State; male, ♂e-4L U.S.N.M.). Salt, 1927, 184: Canaan, Connecticut; J. Bequaert. Halfway House, Mt. Washington, New

Hampshire; C. W. Johnson. Maine. Bilby, Alberta; George Salt.

New record: Edmonton, Alberta; 23 June 1924; George Salt; male, ♀-3L.

Ancistrocerus bacu (Sauss.). New records: Soledad, Cuba; 3 April 1926; J. Bequaert; female, ♂-e3L, ♂ 4R. Hoyo Colorado, Cuba; Oct. 1923; C. Enamorado; female, ♂ p-4L.

Ancistrocerus birenimaculatus (Sauss.). Salt, 1927, 184: Flushing, New York; J. Bequaert, Newfoundland, New Jersey.

New records: vicinity of New York, New York; ex nest; 1924; female, ♂ p-4L; male, ♂ p-3R; male, ♂ p-4R; male, ♂ p-4L male, ♂ p-4R (all A.M.N.H.).

Ancistrocerus bradleyi (Robt.). Robertson, 1910, 324 (as *A. clypeatus* (Robt.)); Carlinville, Illinois; 24 May, 31 May; Chas. Robertson. Salt, 1927, 183: no data.

Ancistrocerus campestris (Sauss.). Pierce, 1909, 180: Missouri; C. V. Riley; ♂ e (U.S.N.M.).

Ancistrocerus capra (Sauss.). Pierce, 1911, 506: in error for *A. albophaleratus* (Sauss.).

Ancistrocerus catskillensis (Sauss.). Salt, 1927, 184: Forest Hills, Massachusetts; L. H. Taylor. Auburndale, Massachusetts; C. W. Johnson. Keene Valley, New York; H. Notman. Colebrook, Connecticut; W. M. Wheeler. Salt, 1927, 184 (as *A. waldenii* (Vier.)): Forest Hills, Massachusetts; O. E. Plath.

New record: Put-in-Bay, Bass Island, Ohio; 1-10 July; C. H. Kennedy; male, ♀-4R.

Ancistrocerus clypeatus (Robt.). Robertson, 1910, 324:= *A. bradleyi* (Robt.).

Ancistrocerus fulvipes (Sauss.). Pierce, 1909, 180 (As *O. colon* Cresson): Mound, Louisiana; 12 May; C. R. Jones; ♀ of *Pseudoxenos jonesi* described p. 138. Salt, 1927, 184: Lee County, Texas; G. Birkman. New Braunfels, Texas; 27 June 1917; J. Bequaert; male, ♂ e-4L.

Ancistrocerus hæmatodes (Brullé). New record: Canary Islands; ♀-3L (Cornell Univ.).

Ancistrocerus histrio (Lepel.). Robertson, 1910, 325: Inverness, Florida; 20 and 24 March; Chas. Robertson. Pierce, 1911, 506: Inverness, Florida; 20 March; Chas. Robertson; ♀ of *Pseudoxenos histrionis* described p. 500. Salt, 1927, 184: Inverness, Florida; Chas. Robertson.

Ancistrocerus histrionalis (Robt.). Robertson, 1910, 324: Carlinville, Illinois; 5 and 27 Aug.; Chas. Robertson. Pierce, 1911, 506: Carlinville, Illinois; 27 Aug.; Chas. Robertson; ♀ of *Pseudoxenos robertsoni* described p. 501. Salt, 1927, 184: no data.

Ancistrocerus parietum (Linn.). Saunders, 1872, 44: Corcyra; Oct.; ♂ of *Pseudoxenos schaumii* described. Ogloblin, 1925, Bull. Ent. Pologne 3, 120: Mielnica, Poland; 20 Aug. 1922; V. Noskiewicz; male 4 ♂ p, ♀, and triungulinids of *Pseudoxenos schaumii* Saunders. Salt, 1927, 184: Ithaca, New York.

Ancistrocerus pertinax (Sauss.). Pierce, 1909, 180: National Park, Wyoming; 31 July; male.

Ancistrocerus sexcingulatus Ashmead. Pierce, 1911, 507: Florissant, Colorado; 26 June 1907; S. A. Rohwer.

Ancistrocerus tigris (Sauss.). Robertson, 1910, 324: Carlinville, Illinois; 23 Sept.; Chas. Robertson. Pierce, 1911, 501: from above specimen describes ♀ of *Pseudoxenos tigridis*. Salt, 1927, 184: Ramsey, New Jersey; 6 and 16 June 1916; J. Bequaert; male, ♀-3R; male, ♂ p-4L. Fort Lee, New Jersey; 3 Sept. 1916; female, ♂ p-4L. Falls Church, Virginia; 18 Sept.; N. Banks; female, ♀-3L, ♂ p-4R (M.C.Z.). Glencarlyn, Virginia; 26 Sept.; N. Banks; female, ♀-3L (M.C.Z.). Melsh, Pennsylvania; female, ♀-3L (M.C.Z.). Colebrook, Connecticut; 6 Sept. 1921; W. M. Wheeler; female, ♀-3L, ♀-4R. Colebrook, Connecticut; 23 Aug. 1919; W. M. Wheeler; female, ♀-4R.

New record: Put-in-Bay, Bass Island, Ohio; 1-10, July; C. H. Kennedy; male, ♀-3L.

Ancistrocerus waldenii (Vier.). Salt, 1927, 185: in error for *A. catskillensis* (Sauss.).

New record: Montreal, Quebec; W. Couper; female, ♂ p-4L (U.S.N.M.).

Monobia quadridens (Linn.). Pierce, 1909, 180: Wolfe City, Texas; 31 May; ♀. Orange, Louisiana; 23 Aug.; F. C. Bishopp; ♀ of *Monobiaphila bishoppi* described p. 139.

New records: Pensacola, Florida; 11-14 Oct. 1914; female, ♀-4L, ♀-4R (A.M.N.H.). New York, New York; male, ♀-3R, ♀-3L, ♂ e-5R, ♂ e-5L (A.M.N.H.). Yaphank, Long Island, New York; 12 July; male, ♀-3R, ♂ p-5L (A.M.N.H.). Paterson, New Jersey; 21 July; male, ♀-4L (A.M.N.H.).

Montezumia sp. near **brunnea** Smith. Salt, 1927, 183: Rio Salado, Chaco de Santiago del Estero, Argentina; female.

Montezumia infernalis (Spinola). Salt, 1927, 183: Villarica, Paraguay; 1923; female.

New records: Chapada, Brazil; March; female, ♂ p-4R, ♂ p-5L (A. N. S. P.). Paraguay; female, ♀-4L (A.M.N.H.).

Montezumia leprieurii (Spinola). Spinola, 1841, Ann. Soc. Ent. France 10, 128 (as *Odynerus leprieurii* Spinola): Cayenne, French Guiana; female, ♂ e-5.

Montezumia vigilii Brèthes. Brèthes, 1923, 45: Cordoba, Rep. Argentina; ♀ of *Montezumiaphila vigili* described.

Polybiinæ

Nectarina lecheguana (Latr.). New record: Tacna, Rio Putumayo, Peru; 28 Aug. 1920; Cornell Univ. Exped.; female, ♀-5R.

Polybia sericea (Olivier). Smith, 1859, 131: Brazil; female, ♀-4.

Mischocyttarus flavitarsis (Sauss.). Pierce, 1918, 490 (as *Megacanthopus flavitarsis* [Sauss.]): Stone Cabin Ca-

nyon, Santa Rita Mts., Arizona; 25 Aug. 1913; W. D. Pierce.

Clypeopolybia duckei Brèthes. Brèthes, 1923, 46: Bolivia; female, ♀ of *Clypoxenos americanus* described.

Belonogaster brunneus Ritsema. New record: Lenga Town, Liberia; 16 Aug. 1926; J. Bequaert; male, ♀-4L.

Belonogaster dubius Kohl. du Buysson, 1909, 236: female, 4L.

Belonogaster elegans Gerst. See *B. lateritius* var. *elegans* (Gerst.).

Belonogaster filiventris (Sauss.). Salt, 1927, 185: La Panda, Katanga, Belgian Congo; 2 Oct. 1920; Mich. Bequaert; female.

Belonogaster griseus (Fabr.). Saunders, 1872, 36: Africa ♀. Saunders, 1872, 36 (as *B. rufipennis* Degeer): Africa; ♂ e and ♀. du Buysson, 1909, 249; female, ♂ p-4R.

New record: Boma, Congo; 16 June 1915; Lang and Chapin; female, ♂ p-5L (A.M.N.H.).

Belonogaster guerini (Sauss.). du Buysson, 1909, 226: male. 5R.

Belonogaster junceus (Fabr.). Smith, 1859, 130: Tripoli; ♀. Salt, 1927, 185: Masinga Archipelago, Victoria Nyanza; J. Carl.

New records: Medje, Belgian Congo; Jan.; Lang and Chapin; female, ♂ e-3R (A.M.N.H.). Stanleyville, Belgian Congo; 8 Aug. 1909; Lang and Chapin; male, ♀-4R (A.M.N.H.). Faradje, Belgian Congo; Sept. 1912; Lang and Chapin; female, ♀-3L (A.M.N.H.). Moala, Liberia; 3 Nov. 1926; J. Bequaert; male, ♂ p-6L. Gbanga, Liberia; 12 Sept. 1926; J. Bequaert; female, ♂ p-4L; female, ♀-4L; and female, ♂ e-3L, ♂ e-4L, ♀-4R.

Belonogaster lateritius Gerst. var. **elegans** (Gerst.). Zavattari, 1909, Ruwenzori Rel. Sci. 1, 212 and 271-273: Butiti, Uganda, July; ♀. Pierce, 1911, 498: from above

specimen describes ♀ and triungulinids of *Belonogastechthrus zavattarii.*

Belonogaster pusillus Kohl. du Buysson, 1909, 239: worker, e-4L.

New record: Garamba, Belgian Congo; July 1912; Lang and Chapin; female, ♂ e-4L (A.M.N.H.).

Belonogaster rufipennis (Degeer). Saunders, 1872, 36:= *B. griseus* (Fabr.).

Belonogaster turbulentus Kohl. du Buysson, 1909, 240: female, ♀-4R.

Ropalidiinæ

Ropalidia cincta (Lepel.). Salt, 1927, 185: Gali, Belgian Congo; J. Bequaert; male.

Ropalidia ferruginea (Fabr.). Horne, 1870, 170: North-west Provinces of India.

Ropalidia nobilis (Gerst.). Salt, 1927, 185: Lisala, Congo; Oct. 1924; female, ♂ e-5R.

Polistinæ

Polistes spp. Saunders, 1872, 36: Caffra; ♂. Fenyes, 1901, Ent. News 12, 90: Mount Arlington, New Jersey (probably *P. fuscatus* var. *pallipes* [Lepel.]). Muir, 1906, Bull. Haw. S. P. Assoc. 2, 9: Honolulu, Hawaii. Pierce, 1909, 184: Virginia; ♂ (A.N.S.P.). Victoria, Texas; 27 June; C. R. Jones; 25 Sept.; J. C. Crawford; ♀ and ♂ p of *Xenos hunteri* described p. 130. Hat Creek, Sioux County, Nebraska; Aug.; ♀ and ♂ e of *Xenos bruneri* Pierce (described?). Schrader, 1924, 162: Connecticut; New York; Pennsylvania; District of Columbia; Maryland. Leonard, 1928, Cornell Univ. Agric. Exp. Station Memoir 101, 521: Staten Island, New York.

Polistes americanus Fabr. See *P. crinitus* var. *americanus* (Fabr.).

Polistes anaheimensis Provancher. Pierce, 1918, 489:=*P. fuscatus* var. *bellicosus* (Cresson).

Polistes annularis (Linn.). See *P. canadensis* var. *annularis* (Linn.).

Polistes aurifer Sauss. See *P. fuscatus* var. *aurifer* (Sauss.).

Polistes bellicosus Cresson. See *P. fuscatus* var. *bellicosus* (Cresson).

Polistes canadensis (Linn.). Pierce, 1909, 182: Texas; ♂ e. See also *P. canadensis* var. *metricus* Say. Hoffman, 1914, Zool. Anz. 45, 99: Uruguay; Bohls; ♂, ♀, and triungulinids of *Xenos bohlsi* described.

Polistes canadensis (Linn.) var. **annularis** (Linn.). Brues, 1903, 242 and 246: Austin, Texas; May 1901; C. T. Brues; ♂ of *Xenos pallidus* described. Brues, 1905, 291: Texas; ♂ and ♀ of *Xenos pallidus* Brues, and ♂ and ♀ of *Xenos nigrescens* Brues. Pierce, 1909, 181 and 182: Paxton, Texas; 9 Aug.; W. D. Pierce; ♀. Rosser, Texas; Sept. and Oct.; F. C. Bishopp and C. R. Jones; ♂ and ♀ of *Xenos pallidus* Brues. Agricultural College, Mississippi; ♀. Bennington, Indian Territory; 28 Aug.; J. C. Crawford. Victoria, Texas; 16 July; W. E. Hinds; female, ♀-4R, ♀-5L (U.S.N.M.). Texas; G. W. Belfrage; male, ♂ p-2R, ♂ p-6L (U.S.N.M.). Plummer's Island, Maryland; Nov. 1907; W. P. Hay and W. L. McAtee; ♂ p and ♀ of *Xenos pallidus* Brues. Pierce, 1918, 489: Louisville, Nebraska; 2 Aug. 1914; H. A. Jones and E. G. Anderson; 7 females, ♂ of *Xenos pallidus* Brues. Omaha, Nebraska; 20 Aug. 1913; L. T. Williams; female, ♀ of *Xenos pallidus* Brues. New Orleans, Louisiana; E. Foster. Salt, 1927, 185: Mongolia County, West Virginia; L. H. Taylor; male and 2 workers. Rau, 1929, Bull. Brooklyn Ent. Soc. 33, 231: Kirkwood, Missouri; P. Rau; 2 females.

New records: Orlando, Florida; 7 Dec. 1906; female, ♀-5L; female, ♀-5L; female, ♂ e-2R, ♂ e-3R, ♀-5R, ♀-5L; female, ♀-4L, ♂ e-3R (all U.S.N.M.). Orlando, Florida; 17 June 1907; Chittenden; female, ♀-5R (U.S.N.M.).

Polistes canadensis (Linn.) var. **lanio** (Fabr.). New record: Las Loras, near Puntarenas, Costa Rica; 18 Sept. 1905; F. Knab; female, ♀-5R (U.S.N.M.).

Polistes canadensis (Linn.) var. **metricus** (Say). Note: Northern records of *P. metricus* Say refer to *P. fuscatus* var. *pallipes* (Lepel.). Pierce, 1909, 182 (as *P. canadensis* (Linn.); Mound, Louisiana; 20 Aug. 1906; F. C. Bishopp; female, ♂ e-3L (U.S.N.M.). Pierce, 1909, 183 (as *P. navajoe* Cresson): Metacomba Key, Florida; March 1898; G. N. Collins; female, ♂ e-3L (U.S.N.M.). Pierce, 1909, 184 (as *P. rubiginosus* Lepel.): Onaga, Kansas; Crevecoeur; female, ♂ e-3R (U.S.N.M.).

Polistes canadensis (Linn.) var. **unicolor** (Lepel.). Lepeletier, 1836, Hist. Nat. Ins. Hym. 1, 520: Cayenne, French Guiana; Doumerc; worker, ♂ e-5.

Polistes carnifex (Fabr.) Pierce, 1909, 182: Mexico; ♂ p and ♂ e. New record: "Colom"; C. F. Baker; female, ♂ p-4R, ♀ -5L (U.S.N.M.).

Polistes cavapyta Sauss. Brèthes, 1923, 43; San Luis, Rep. Argentina; ♀ of *Xenos argentinus* described.

Polistes crinitus (Felton). Pierce, 1909, 182: See *P. crinitus* var. *americanus* (Fabr.). Pierce, 1918, 490: New Orleans, Louisiana; E. Foster (this record is very doubtful as *P. crinitus* probably does not occur on the American mainland). Salt, 1927, 185: Sanchez, Rep. Dominicana; 17-21 May 1915; female, ♂ p-4R; female, ♂ p-3L; female, ♂ p-3R; female, ♂ e-4L; female, ♂ p-3R, ♂ p-4L.

Polistes crinitus (Felton) var. **americanus** (Fabr.). Smith, 1859, 131: North America; female, ♂ e. Hubbard, 1892, Can. Entom. 24, 258: Florida. Pierce, 1909, 122 and 182 (based on Hubbard's specimens): Crescent City, Florida; 6 April; H. G. Hubbard; 14 ♂, ♀, and triungulinids of *Xenos hubbardi* (Pierce, 108, Proc. Ent. Soc. Wash. 9, 84). These three records are certainly erroneous as *P. crinitus* var. *americanus* (Fabr.) does not occur on the American mainland. Salt, 1927, 185: Mayaguez, Porto Rico; 16-16 Febr. 1914; female, ♂ p-4R; female, ♀ -5L. Coamo Springs, Porto Rico; 17-19 July 1914; female, ♂ e-3L, ♀ -5L. Manati, Porto Rico; 27-29 June

1915; female, ♀-5L. Cayey, Porto Rico; 30-31 May 1915; female, ♀-5R. Jayuya, Porto Rico; 6 Jan. 1915; female, ♂ p-3R. Aibonito, Porto Rico; 14-17 July 1914; female, ♂ p-3R.

New record: Porto Rico; female, ♀-3L (Hamburg Mus.).

Polistes cubensis Lepel. Pierce, 1909. 183 (as *P. lineatus* (Fabr.)): Cuba; Palmer and Riley; ♂ p and ♂ e (one specimen seen: female, ♂ e-4R (U.S.N.M.).

Polistes diadema Latr. See *P. gallicus* var. *diadema* (Latr.).

Polistes erythrocerus Cameron. Cameron, 1900, Ann. Mag. Nat. Hist. (7) 6, 419: Kamakura, Japan; George Lewis; female.

Polistes flavus Cresson. Pierce, 1909, 182=*P. fuscatus* var. *aurifer* (Sauss.).

Polistes fuscatus (Fabr.). See *P. fuscatus* var. *pallipes* (Lepel.).

Polistes fuscatus (Fabr.) var. **apachus** (Sauss.). Brues, 1903, 242 (as *P. texanus* Cresson) : Austin, Texas; ♂ e. Anonymous, 1903, Ent. News 14, 274 (as *P. texanus* Cresson) : Pecos, Texas. Pierce, 1909, 184 (as *P. texanus* Cresson) : New Mexico; C. F. Baker; female, ♂ e-3R, ♂ e-3L (U.S.N.M.). Victoria, Texas; 7 July; C.M. Walker; ♂ p. Victoria, Texas; 25 July; C.R. Jones; ♀ and ♂ e of *Xenos texani* described p. 132. Pecos, Texas; 27 Febr., 25 and 30 Sept.; A. E. Brown; ♂, ♂ p, and ♀ of *Xenos pecosensis* described p. 128.

Polistes fuscatus (Fabr.) var. **aurifer** (Sauss.). Perkins, 1899, Fauna Hawaiiensis 1, 29: Lanai and Hawaii. Pierce, 1909, 182: Washington State; ♂. California; ♂ p. Folsom, California; 10 and 12 July; female, ♂ e-3R, ♂ e-4L; and female, ♂ e-4L (both U.S.N.M.). Pierce, 109, 182 (as *P. flavus* Cresson) : Colorado; ♂ p (U.S. N.M.). Pierce, 1911, 507: Palo Alto, California; Febr. 1892; W. G. Johnston; ♂ e and ♀ of *Xenos auriferi* described p. 498. Terry, 1912, Proc. Haw. Ent. Soc. 2, 181: Hawaii. Ehrhorn, 1915, Proc. Haw. Ent. Soc. 3,

86: Honolulu, Oahu, Hawaii. Pierce, 1918, 489: Auburn, California; 14 Aug. 1915; L. Bruner; female, ♀. Williams, 1927, Proc. Haw. Ent. Soc. 6, 463: Hawaii.

New records: "W. T."; male, ♂ p-4L (A.N.S.P.). No data; female, ♂ e-3R (A.N.S.P.).

Polistes fuscatus (Fabr.) var. **bellicosus** (Cresson). Pierce, 1909, 182 (with doubt): Natchitoches, Louisiana; 15 Sept.; ♂. Pierce, 1918, 489: Stone Cabin Canyon, Santa Rita Mts., Arizona; 24 Aug. 1913; W. D. Pierce; ♂ p. Pierce, 1918, 489 (as *P. anaheimensis* Provancher): Auburn, California; 23 July 1915; L. Bruner; male, ♀ of *Xenos californicus* Pierce (described?).

Polistes fuscatus (Fabr.) var. **pallipes** (Lepel.). Kirby, 1813, 116 (as *P. fuscatus* (Fabr.).: Newbury, Massachusetts; ♂ and ♀ of *Xenos peckii* described. Austin, 1882, Journ. Bost. Zoöl. Soc. 1, 12 (as *P. metricus* Say): Reading, Massachusetts. Dury, 1902, 180 (as *P. fuscatus* [Fabr.]): Cincinnati, Ohio; ♂. Brues, 1903, 241 (as *P. metricus* Say). Pierce, 1909, 183: Marion, Massachusetts; 2-12 Sept.; F. C. Bowditch; ♂ and ♀ of *Xenos bowditchi* described p. 130. Cincinnati, Ohio; June-Sept.; ♂, ♀ ♂ p, and ♀ e of *Xenos bowditchi*. Pierce, 1909, 183 (as *P. metricus* Say): Colebrook, Connecticut; Aug.; W. M. Wheeler; ♂ and ♀ of *Xenos wheeleri* described p. 129. Washington, D.C.; 6 Sept.; ♂ of *Xenos wheeleri* (Pierce). Ithaca, New York; Aug. and Sept. Detroit, Michigan; ♂ and ♀ of *Xenos bruesi* described p. 124. Chicopee, Massachusetts; F. Knab; female, ♂ e-3stR, ♂ e-4R, ♂ e-4L; and female, ♂ e-4R (both U.S.N.M.). Pierce, 1909, 183 (as *P. instabilis* Sauss.): New Orleans, Louisiana; July; female, ♂ e-4L (U.S.N.M.). Pierce, 1909, 184 (as *P. variatus* Cresson): Washington, D.C.; female, ♂ p-3L, ♂ e-4R (U.S. N.M.). Wheeler, 1910, 277 (as *P. metricus* Say): Colebrook, Connecticut; Aug. 1900; W. M. Wheeler. Pierce, 1911, 507 (as *P. metricus* Say): Cornell Univ., Ithaca, New York. Salt, 1927, 185: Colebrook, Robertsville, and Chapenville, Connecticut; W. M. Wheeler.

New records: Cincinnati, Ohio; 16 Sept. 1905; male, ♂ e-3L (U.S.N.M.). Pennsylvania; C.F. Baker; male, ♂ p-4R (U.S.N.M.). Washington, D.C.; Oct. 1884; male, ♂ e-4R, ♀-5L (U.S.N.M.).

Polistes fuscatus (Fabr.) var. **perplexus** (Cresson). Pierce, 1909, 183: Texas; ♂ e.

Polistes fuscatus (Fabr.) var. **rubiginosus** (Lepel.). Brues, 1903, 242: Austin, Texas; Oct. 1901; C. T. Brues; ♂ and ♀ of *Xenos nigrescens* described p. 247. Brues, 1905, 290: Paris, Texas; 22 May; C. T. Brues: ♀ and triungulinids of *Xenos nigrescens* Brues. Pierce, 1909, 184: Round Mountain, Texas; ♂ e and ♀. Logansport, Louisiana; 6 June; W. D. Pierce; ♂ p and ♀ of *Xenos rubiginosi* described p. 132. New Boston, Texas; 26 Sept. 1906; F. C. Bishopp; male, ♂ e-3L, ♂ e-4R, ♂ e-4stR; and male, ♂ p-3L, ♂ e-4stL, ♂ e-5R (both U.S.N.M.). Henrietta, Texas; 50ct. 1906; F. C. Bishopp; male, ♂ e-4L (U.S.N.M.). Mineola, Texas; 19 July 1906; Bishopp and Jones; female, ♂ e-2R, ♂ e2-L, ♂ e-3stR, ♂ e-4stL, ♀-4L, ♂ e-4R, ♀ e-5L (U.S.N.M.). Waco, Texas; 29 Aug. 1906; F. C. Bishopp; female, ♂ e-3L, ♀ e-4R, (♀ removed?) of *Xenos pecosensis* described p. 128 (U.S.N.M.). Texas; ♀ of *Xenos maximus* described p. 132. See also *P. canadensis var. metricus* (Say). Pierce, 1911, 507: Arlington, Texas; 30 Sept.; ♂ e. Tallulah, Louisiana; 29 Jan. and 16 Febr.; V. I. Safro; ♂ e and ♀.

Pierce, 1918, 490: New Orleans, Louisiana; E. Foster.

New record: Victoria, Texas; 15 June 1904; female, ♂ e-2L (U.S.N.M.).

Polistes fuscatus (Fabr.) var. **variatus** (Cresson.) Brues, 190, 241: parasitized by *Xenos peckii* Kirby. Pierce, 1909, 184: in error for *P. fuscatus var. pallipes* (Lepel.). Robertson, 1910, 324: Carlinville, Illinois; 30 Sept.; Chas. Robertson. Wheeler, 1910, 377: Chicago, Illinois; W. M. Wheeler. Pierce, 1911, 507: Church's Island, Maryland; 3 Nov.; W. L. McAtee; ♂ and ♀. Pierce, 1918, 490: Clarksville, Tennessee; 10 Nov. 1915;

E. E. Crumb; 4 ♂ e. Lanham, Maryland; 24 Nov. 1915; H. F. Loomis; ♂ p and ♀. Salt, 1927, 185: Carlinville, Illinois; Chas. Robertson; male, ♀-5L.

Polistes gallicus (Linn.). Rossi, 1793, Bull. Sci. Soc. Philomath. Paris 1, 49: Italy; ♂ of *Xenos vesparum* described. Rossi, 1807, Fauna Etrusca 2, 136. Kirby, 1813, 116: Europe; ♂ and ♀ of *Xenos rossii* described. Jurine, 1818, Mem. R. Accad. Sci. Torino 23, 63; Italy. Heyden, 1836, lxxix: ♀. Rosenhauer, 1842, Stettin. Ent. Zeit. 2, 53: Germany. Saunders, 1853, 125: Albania. Saunders, 1866, Proc. Ent. Soc. Lond. (3) 2, 116. Saunders, 1872, 36: Europe; *Xenos jurinei* described p. 39. Rouget, 1873, 268: France. Nassanow, in Hofeneder, 1910, 3: Cairo, Egypt. Léveillé, 1895, Bull. Soc. Ent. France (1895), vi: Gryon, Canton de Vaud, Switzerland; Aug. 1894. Pierce, 1909, 183: Innsbruck, Austria; 28 Oct.; Karl Hofeneder; worker, ♂ e-3R, ♂ e-5L U.S.N.M.). Rabaud and Millot, 1927, C.R. Soc. Biol. 96, 944. Salt, 1927, 185: no data; worker, ♂ e-4R.

Polistes gallicus (Linn.) var. **diadema** (Latr.). Rouget, 1873, 268: France. Hofeneder, 1910, 5 footnote: female, 6 ♂ p.

Polistes hebraeus (Fabr.). Horne, 1870, 171; Maxwell-Lefroy and Howlett, 1909, 395; and Pierce, 1918, 490: =*P. olivaceus* (Degeer).

Polistes instabilis Sauss. Smith, 1859, 131: Brazil; female, 4 ♂ e and 5 ♀; incorrectly determined. Pierce, 1909, 183: in error for *P. fuscatus* var. *pallipes* (Lepel.).

Polistes lineatus (Fabr.). Pierce, 1909, 183:=*P. cubensis* Lepel.

Polistes major Beauvois. Pierce, 1918, 490: District Federal, Mexico; J. R. Inda; 4 ♂ e and 4 ♂ p.

Polistes marginalis (Fabr.). Schulz, 1905, Hymen. Studien. 15: Boma, Belgian Congo; worker, 5 parasites.

New records: Luvungi, Belgian Congo; 30 Jan. 1927; J. Bequaert; female, ♂ e-3L, ♂ e-4L, ♂ e-4R. Kwamouth, Belgian Congo; 13 Dec. 1926; J. Bequaert; male

♂ e-3L, ♂ e-3stL, ♀ -3R, ♀ -3R, ♂ e-5R; and male, ♀ -3stR, ♂ p-4R, ♀ -6L.

Polistes metricus Say. See *P. canadensis* var. *metricus* (Say) and *P. fuscatus* var. *pallipes* (Lepel.).

Polistes minor Beauvois. Pierce, 1918, 490: in error for? (*P. minor* does not occur in Louisiana, the locality given by Pierce).

Polistes navajoe Cresson. Pierce, 1909, 183: in error for *P. canadensis* var. *metricus* (Say).

Polistes olivaceus (Degeer). Horne, 1870, 171: North-west Provinces of India. Maxwell-Lefroy and Howlett, 1909, Indian Insect Life, 395; India; ♂. Pierce, 1918, 490: Pusa, Bihar, India; 12 April 1911; G. R. Dutt; ♂ and ♀.

Polistes opinabilis Kohl. Fahringer, 1919, Zeitschr. wiss Ins. biol. **15**, 48: Pola, Istria, Italy.

Polistes pallipes Lepel. See *P. fuscatus* var. *pallipes* (Lepel.).

Polistes perplexus Cresson. See *P. fuscatus* var. *perplexus* (Cresson).

Polistes rubiginosus Lepel. See *P. fuscatus* var. *rubiginosus* (Lepel.).

Polistes stigma (Fabr.). Horne, 1870, 172: North-west Provinces of India.

Polistes texanus Cresson=*P. fuscatus* var. *apachus* (Sauss.).

Polistes unicolor Lepel. See *P. canadensis* var. *unicolor* (Lepel.).

Polistes variatus Cresson. See *P. fuscatus* var. *variatus* (Cresson).

Polistes versicolor (Olivier). Brèthes, 1923, 44; Buenos Aires, Rep. Argentina; ♂ and ♀ of *Xenos bonariensis* described.

Vespinæ

Vespa acuta Lefebvre in Ann. Soc. Ent. France **4**: xlv; 1835. (a nomen nudum).

Vespa carolina Linn. Pierce, 1918, 489: Clarksville, Tennessee; 19 Oct. 1915; S. E. Crumb; male, ♂ p.

Vespa concolor Kirby. Kirby, 1813, 118: ♂ e.

Vespa crabro Linn. Pierce, 1909, 181 Japan; female, ♀ of *Vespaexenos crabronis* described p. 134.

Vespa ducalis Smith, du Buysson, 1906, Revue d'Entom. 25, 11: Hué, Annam; E. Fleutiaux; worker, ♂ p-4R. Parasite extracted and described as the ♂ of *Vespaexnos moutoni* du Buysson. Pierce, 1903, 134: proposes *Vespaexenos buyssoni* new name.

Vespa lama du Buysson. du Buysson, 1906, 175 (additional data in du Buysson, 1905, 580); Sikkim, India; ♀-5R.

Vespa magnifica Smith. du Buysson, 1903, 175 (additional data in du Buysson, 1905, 526): Yun-nam, China; male, ♂ p-4st. Tsé-kou, China; worker, ♀-5. ♀ of *Vespæxenos moutoni* du Buysson.

Vespa mandarinia Smith. du Buysson, 1903, 175 (additional data in du Buysson, 1905, 522): Ngan-hoei, China; R. P. Mouton. Yng-chan, China. ♀ of *Vespæxenos moutoni* described p. 175 .

New records: Kyoto, Japan; female, ♀-5R; and female, ♀-5R (both A.N.S.P.).

Vespa mongolica André. New record: Kyoto, Japan; female, ♂ p-4R (A.N.S.P.).

Vespa nigrans du Buysson. du Buysson, 1903, 175: Yun-nam, China. Tsé-kou, China. ♀ of *Vespaexenos moutoni* (du Buysson).

Vespa vulgaris Linn. Heyden, 1836, lxxiv: Stuttgart, Germany; Van Roser; ♀.

Groups Stylopized

Our list includes members of eight of the eleven subfamilies of Vespidæ. The Euparagiinæ, Gayellinæ, and Stenogastrinæ are unrepresented. Of the Gayellinæ we have examined only about half a dozen specimens for

Strepsiptera, and of the Stenogastrinæ and Euparagiinæ fewer than fifty, so we are not surprised that parasitized examples have not yet turned up.

There are, however, some rather puzzling lacunæ. Among the Eumeninæ, *Synagris* forms one; we have deliberately examined over four hundred specimens without finding any evidence of stylopization. That more infested individuals of Polybiinæ, and especially of *Polybia, Metapolybia,* and *Mischocyttarus,* are not known is surprising when one considers their abundance in the tropics; we ourselves have examined some hundreds of specimens especially from the West Indies and Colombia without finding a single parasitized example. The genue *Vespa* contributes several species to the list but the common forms, of which one might expect numerous records if they are subject to strepsipterous attack, are conspicuously absent.

The data, however, are lacking rather than actually negative; and in spite of these contrary indications in certain groups it has frequently occurred to us, as we gathered the records, that sooner or later stylopized specimens will be found in most, if not all, of the genera of Vespidæ. The majority of the common genera are already known to be attacked, at any rate occasionally, and our lack of records for the rarer groups is not surprising when one considers the very low frequency of stylopization in the Vespidæ as a whole. Until 1927 no representative of the Zethinæ had appeared in the host lists; now five stylopized specimens belonging to three species are known. The Ropalidiinæ were long included solely on the basis of Horne's record from India; three specimens are listed above. It was not until 1909 that Pierce recorded the first case of stylopization in *Monobia,* and until 1923 that *Montezumia* was first found infested by Brèthes. In his monograph of *Nectarina,* du Buysson (1905*a*) mentioned expressly that he had not seen a stylopized specimen of that genus; Crawford (Pierce, 1909, p. 23) studied 2500 individuals of *Nectarina lecheguana* from one nest, without finding a single example parasitized; and we ourselves examined several hundreds of specimens before finding the infested one recorded above. It would seem, therefore, that infested

individuals are eventually found in most groups. We hope that the publication of this list will stimulate those interested in the taxonomy of the Vespidæ to mention the stylopized examples contained in the collections they study.

The Frequency of Stylopization

The frequency of stylopization, then, varies from zero in certain groups to as much as 25% in particular collections of *Polistes* (Wheeler, 1910; Schrader, 1924). In our search for stylopized specimens we have kept some count of the frequency of their occurrence in several collections and in different taxonomic groups, and are able to give the following figures. Unfortunately we did not always make notes upon the frequency, and while the following numbers are proportionate, they do not represent our entire search.

Vespidæ	of 16,932	specimens	157	stylopized, or	0.93%
Masaridinæ	256	"	0	"	0 %
Raphiglossinæ	8	"	0	"	0 %
Zethinæ	158	"	4	"	2.53%
Eumeninæ	14,926	"	138	"	0.92%
Eumenes	1,651	"	11	"	0.67%
Odynerus s. l.	4,316	"	35	"	0.81%
Monobia	271	"	4	"	1.48%
Montezumia	152	"	0	"	0 %
Synagris	443	"	0	"	0 %
Pterochilus	74	"	0	"	0 %
Alastor	65	"	0	"	0 %
Polybiinæ	623	"	8	"	1.28%
Ropalidiinæ	160	"	2	"	1.25%

No records were kept of the frequency of stylopized Polistes in collections because much more accurate data based on field counts are available for this genus (see Pierce, 1909, 1911, 1918; Schrader, 1924).

In the American Museum of Natural History is preserved a mud nest of *Ancistrocerus birenimaculatus*, and the twenty-two wasps which emerged from it. Five of these twenty-two wasps, or 22.7%, are stylopized; showing that the rate of parasitism in particular nests can be almost as

high in *Ancistrocerus* as it has been reported for particular colonies of *Polistes*.

The Sex of the Host

As far as can be judged from our data both sexes of the host are attacked with equal readiness. The following is a summary of the cases in our list in which the sex of the host is known. In giving these and following figures we have not thought it necessary to incorporate the data so admirably summarized by Pierce (1909, 17-23; 1911, 487-489; 1918, 392-393, 396-397), and have confined ourselves to those in the above list.

	Males	*Females*		*Males*	*Females*
Masaridinæ	8	4	Montezumia	0	5
Zethinæ	1	4	Polybiinæ	4	15
Eumenes	7	8	Ropalidia	1	1
Odynerus s.l.	50	49	Polistes	13	56
Monobia	3	1	Vespa	2	6

Where, as in *Polistes* and the Polybiinæ, decidedly more female than male hosts are known, this must undoubtedly be attributed to the fact that females of these groups are much more commonly collected.

Position of the Parasite in the Host

As would be expected, the parasites extrude in about equal numbers on the two sides of the host. A summary of the cases in our list for which the side is recorded gives 132 on the right and 141 on the left.

A very strong preference is shown for a dorsal position. In our list only ten cases of extrusion between the sternites appear. One of these occurs in *Vespa* and was recorded by du Buysson. Of the nine cases which we have observed, seven occur in *Polistes* and two in *Pachodynerus*. In each of these nine cases the unusual, ventral position is obviously due to crowding, for in four cases the parasite appearing ventrally is one of three in the same host; in two cases one of four; in one case one of five; and in one case, where two

parasites appear between the sternites, there are seven parasites present in the one wasp.

In an earlier paper (Salt, 1927) it has been shown that in *Odynerus (s. l.)* the female parasites usually occur under the third abdominal segment of the host and the males behind, under the fourth segment; while in *Polistes* the male parasites usually lie before, under the third and fourth segments, the females behind under the fifth. The same curious difference, together with additional facts, appear from a consideration of the cases recorded in our list; where the parasites are situated as follows:

Under abdominal segment number		*2*	*3*	*4*	*5*	*6*
In Eumenes . . .	♂ parasites	—	1	4	—	—
	♀ parasites	—	10	—	—	—
In Odynerus . . .	♂ parasites	—	5	17	7	—
	♀ parasites	1	25	24	—	—
In Pachodynerus. .	♂ parasites	—	1	9	1	—
	♀ parasites	3	13	4	—	—
In Ancistrocerus .	♂ parasites	—	2	12	—	—
	♀ parasites	—	8	3	—	—
In Monobia . . .	♂ parasites	—	—	—	3	—
	♀ parasites	—	3	3	—	—
In Montezumia . .	♂ parasites	—	—	1	2	—
	♀ parasites	—	—	1	—	—
In Belonogaster . .	♂ parasites	—	2	5	1	1
	♀ parasites	—	1	5	—	—
In Polistes	♂ parasites	5	26	27	5	1
	♀ parasites	—	3	3	14	1
In Vespa	♂ parasites	—	—	3	—	—
	♀ parasites	—	—	—	4	—

For the Masaridinæ, Raphiglossinæ, and Zethinæ the numbers are too low to be significant, and are not given. The parasites of *Eumenes* clearly take the same position as those of *Odynerus (s. l.)*, the females preferring a position under the third, the males under the fourth abdominal segment. Our separate notes for *Odynerus (s. st.)*, *Pachodynerus*, and *Ancistrocerus* serve to show that in these genera the parasites act similarly, and that our former treatment

of them (1927) as a single group, *Odynerus s. l.*, was quite permissible. The numbers for *Monobia* and *Montezumia* are again very low but seem to indicate agreement with the condition found in *Odynerus*. The figures for *Belonogaster* suggest preference of both sexes for the fourth segment. The parasites of *Vespa* apparently agree with those of *Polistes*, the males lying anteriorly to the females. We have, then, the Eumeninæ forming one group, *Polistes* and *Vespa* another; the difference being clearly shown in the totals, as follows:

Under abdominal segment number		*2*	*3*	*4*	*5*	*6*
Eumeninæ . . .	♂ parasites	—	9	43	13	—
	♀ parasites	4	59	35	—	—
Polistes and Vespa	♂ parasites	5	26	30	5	1
	♀ parasites	—	3	3	18	1

Since, in the Vespidæ, the males have seven, the females only six visible abdominal segments, we have examined our records to see whether the sex of the host has any effect on the position of the parasite. Summarizing our records for the two groups shown above, we have the following:

Under abdominal segment number		*2*	*3*	*4*	*5*	*6*
Eumeninæ						
males	♂ parasites	—	4	22	6	—
	♀ parasites	2	23	12	—	—
females	♂ parasites	—	5	20	7	—
	♀ parasites	2	33	22	—	—
Polistes and Vespa						
males	♂ parasites	1	5	9	2	1
	♀ parasites	—	2	—	2	1
females	♂ parasites	4	21	21	3	—
	♀ parasites	—	1	3	15	—

The ♂ and ♀ Xenos found under the sixth abdominal segment of a male Polistes could not have extruded under this segment, of course, in a female host. With this excep-

tion no tendency for the parasites to move back in male hosts is apparent.

The Sex of the Parasite

The parasites listed above include 245 males and 206 females, divided as follows:

Parasites of	♂	♀	*Parasites of*	♂	♀
Masaridinæ	7	3	Monobia	3	8
Zethinæ	3	3	Montezumia	3	2
Eumenes	6	12	Polybiinæ	10	13
Odynerus	32	59	Polistes	144	61
Pachodynerus	11	21	Vespa	5	8
Ancistrocerus	21	16			

It will be seen that male parasites are known, and indeed are common, in all groups; so that no such condition exists in the Vespidæ as in the bee genus *Halictus* where hundreds or even thousands of female parasites are found for each male. The preponderance of male Xenos in Polistes is striking, but except in Odynerus, where an excess of female parasites is indicated, the other numbers are too low to be worthy of discussion.

We have compared the sex of the parasites found in male and female hosts, but as there is no very significant result we do not give the summary in detail. As far as our data go, male and female parasites infest male and female hosts indiscriminately.

Number of Parasites per Host

There is some difficulty in counting the number of parasites per host from published records, as it is not always stated definitely whether the host contained one or several parasites, or whether the several parasites mentioned came from one or more hosts. Our summary, therefore, includes only those cases of which we are quite sure, either from a personal examination of the specimen, or from a definite statement in the record. In the following list we give the

average number of parasites per host, per male host, and per female host.

	host	*male*	*female*		*host*	*male*	*female*
Masaridinæ	2.	1.	4.	Monobia	2.25	2.33	2.
Zethinæ	1.2	1.	1.25	Montezumia	1.33	.....	1.33
Eumenes	1.25	1.	1.5	Belonogaster	1.15	1.	1.20
Odynerus	1.34	1.15	1.52	Polistes	1.75	2.	1.68
Pachodynerus	2.38	2.5	2.29	Vespa	1	1.	1.
Ancistrocerus	1.14	1.	1.3				

In most groups, female hosts support a slightly higher average number of parasites than males.

In Pierce's table of maximum parasitism per individual (1909, p. 26; 1918, p. 397) and in our own notes (1927, p. 189), it is very noticeable that heavily infested Polistes contain largely or exclusively male parasites. Eleven Polistes bearing four or more parasites are mentioned in those tables and four others in the present list; the entire fifteen containing parasites as follows: 1-2 ♂ 2 ♀, 1-3 ♂ 1 ♀, 1-4 ♂, 2-5 ♂, 1-3 ♂ 3 ♀, 1-6 ♂, 1-6 ♂ 1 ♀, 2-7 ♂, 1-8 ♂, 1-9 ♂, 1-10 ♂, 1-11 ♂, 1-15 ♂. There are here included 100 ♂ and 7 ♀. One is led to recall the interesting discovery of Cobb, Steiner, and Christie (1927) who have shown the striking preponderance of male nematodes in heavily infested hosts. In stylopized Eumeninæ as well as in infested bees the opposite seems to hold, and in cases of heavy stylopization, female parasites are in the majority.

The Geographical Distribution of Stylopized Vespidæ

Our list includes vespid hosts from all the continental areas and many islands, and where records are lacking we must, at the present state of our knowledge, attribute their absence to insufficient collecting or study.

Some interesting problems in distribution are furnished by the Strepsiptera. The chance of their establishment in

isolated insular regions must be very remote, much more so than that of their host. Yet the first record of an Odynerus from Bermuda, the holotype and only known specimen of *Odynerus bermudensis* Bequaert, bears a female Strepsipteron. *Polistes fuscatus* var. *aurifer,* which was introduced into the Hawaiian Islands fairly recently, through the agency of man, carried its parasite with it. We list above several stylopized specimens from various islands, more or less remote, of the West Indies, the East Indies, and the Canary Islands.

Since the powers of flight of the host are impaired by stylopization, and female hosts are frequently rendered sterile, it is probable that the introduction of Strepsiptera into distant regions is brought about in the triungulinid stage. Several of these minute larvæ could cling to the body of a perfectly healthy host without seriously burdening it. Brues, indeed, has already reported (1924) the occurrence of triungulins, presumably of the meloid *Horia maculata,* on a bee *(Xylocopa transitoria)* from the Galapagos Islands.

The Problem of Host Specificity

It seems to have been generally assumed that Strepsiptera obtained from different species of hosts are themselves specifically distinct. Pierce (1909, p. 70) stated that as a rule species of Strepsiptera are confined to single species of hosts; and in his classification used tribes as divisions of convenience to unite genera of parasites infesting different families of hosts. Following a decision to unite the vespid groups *Leionotus, Ancistrocerus,* etc., with *Odynerus,* the same author (1911, p. 498) combined the genera *Leionotoxenos* and *Pseudoxenos* parasitic on those groups. Many species and several genera in the Strepsiptera are based solely on the unsatisfactory characters of the female together with the name of the host, which latter one sometimes feels is the more valuable part of the description.

It is not our intention to discuss here the validity of this tacit assumption of host specificity in the Strepsiptera, but some points arising from our redetermination of several

hosts deserve mention. Our records for *Polistes fuscatus* var. *pallipes,* for instance, include hosts reported under the names *P. fuscatus, P. metricus, P. instabilis,* and *P. variatus;* and parasites described as *Xenos peckii, X. bowditchi, X. wheeleri,* and *X. bruesi. Polistes fuscatus* var. *rubiginosus* likewise becomes the host of *Xenos nigrescens, X. rubiginosi, X. pecosensis,* and *X. maximus.* The parasites become similarly scattered among the host species. Until this interesting problem has been seriously investigated it should not be assumed that the hosts and their parasites are related, species to species, and genus to genus; and new species described in the Strepsiptera should stand on their own morphological characters, not on the identity of their hosts.

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ANATRICHIS MINUTA DEJ. A single specimen was taken in Framingham, Mass., on May 10, 1908, and no more have been seen until September 15, 1929, when I found 5 specimens by treading about in the soft soil in a dried-up pond in Acton, Mass. On September 22, I again visited the place and took four more. They were hiding among the small grass-like plants and prostrate vegetation. There is but one record in the New York list of insects.

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